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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				U S APPLICATION NO. (If known, see 37 CFR 1.5)	
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INTERNATIONAL APPLICATION NO PCT/JP00/06009		INTERNATIONAL FILING DATE September 5, 2000		PRIORITY DATE CLAIMED September 7, 1999	
TITLE OF INVENTION LIQUID CRYSTAL DISPLAY DEVICE					
APPLICANT(S) FOR DO/EO/US ONO, KIKUO YONEYA, MAKOTO YAMAMOTO, TSUNENORI HIRAKATA, JUNICHI NAKAYOSHI, YOSHIKI					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.					
1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. 4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))) a. <input type="checkbox"/> is transmitted hereto (required only if not communicated by the International Bureau). b. <input checked="" type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office(RO/US) 6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). 					
Items 11 to 20 below concern document(s) or information included:					
11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input checked="" type="checkbox"/> An assignment document for recording A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input type="checkbox"/> A FIRST preliminary amendment. 14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 15. <input type="checkbox"/> A substitute specification. 16. <input checked="" type="checkbox"/> A change of power of attorney and/or address letter. 17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825. 18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 20. <input checked="" type="checkbox"/> Other items or information: Figs. 1-5,6A-6B,7A-7B,8A-8B,9A-9b,10-41,42A-42B,43-50; Credit Card Payment Form					

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U.S. APPLICATION NO. 107070538			INTERNATIONAL APPLICATION NO PCT/JP00/06009		ATTORNEY'S DOCKET NUMBER 501.41304X00	
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21. The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492(a) (1) - (5)): <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO. \$1040.00 <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$890.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$740.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$710.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).... \$100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$890.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e)). <input type="checkbox"/> 20 <input type="checkbox"/> 30				\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$	
Total Claims	56 - 20 =	36	x \$18.00	\$648.00	
Independent Claims	22 - 3 =	19	x \$84.00	\$1,596.00	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable) 280.00			+ \$280.00	\$280.00	
TOTAL OF ABOVE CALCULATIONS =				\$3,414.00	
<input type="checkbox"/> Applicant claims small entity status See 37 CFR 1.27 The fees indicated above are reduced by 1/2.				\$	
SUBTOTAL =				\$3,414.00	
Processing fee of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(f)) <input type="checkbox"/> 20 <input type="checkbox"/> 30				\$	
TOTAL NATIONAL FEE =				\$3,414.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				\$40.00	
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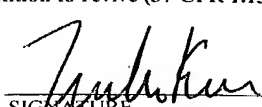
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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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Description

LIQUID CRYSTAL DISPLAY DEVICE DEVICE

Technical Field

The present invention relates to a liquid crystal display device, and more particularly to a so-called "lateral electric field type" liquid crystal display device.

Background of the Invention

A liquid crystal display device which is referred to as a "lateral electric field type" is constituted such that a pair of transparent substrates are arranged to face each other in an opposed manner by way of liquid crystal, and pixel electrodes and counter electrodes which generate an electric field (lateral electric field) parallel to the transparent substrate between the counter electrode and the pixel electrode are formed on each pixel region at a liquid-crystal side of one of such transparent substrates.

With respect to light which passes through the region between the pixel electrode and the counter electrode, a quantity of light is controlled by the driving of liquid crystal to which the above-mentioned electric field is applied.

Such a liquid crystal display device is known as a display device having broad viewing angle characteristics whose display

is not changed even when viewed from a direction oblique to a display surface.

Then, heretofore, the above-mentioned pixel electrode and the above-mentioned counter electrode have been formed of a conductive layer which prevents the transmission of light therethrough.

However, recently, there has been known a liquid crystal display device having a constitution in which counter electrodes formed of a transparent electrode are formed on the whole pixel regions except for peripheries of the pixel regions, and strip-like pixel electrodes which are extended in one direction and are arranged in parallel in the direction intersecting such one direction are formed on the counter electrodes by way of an insulation film.

In the liquid crystal display device having such a constitution, the lateral electric field is generated between the pixel electrode and the counter electrode so that the liquid crystal display device can largely enhance the numerical aperture while still maintaining the excellent broad viewing angle characteristics.

Such a technique is described in, for example, in SID (Society for Information Display) 99 DIGEST : p202 to p205 or Japanese Laid-open Patent Publication 202356/1999.

Disclosure of the Invention

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$\frac{1}{2} \left(\frac{1}{2} + \frac{1}{2} \right) = \frac{1}{2}$

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Fig. 6 is a cross-sectional view showing the constitution of a seal member which is served for fixing respective transparent substrates of the liquid crystal display panel and for sealing liquid crystal in a space defined by respective transparent substrates.

Fig. 7 is a constitutional view showing one embodiment of a gate signal terminal of the liquid crystal display device according to the present invention.

Fig. 8 is a constitutional view showing one embodiment of a drain signal terminal of the liquid crystal display device according to the present invention.

Fig. 9 is a constitutional view showing one embodiment of a counter voltage signal terminal of the liquid crystal display device according to the present invention.

Fig. 10 is an equivalent circuit diagram showing one embodiment of the liquid crystal display device according to the present invention.

Fig. 11 is a timing chart showing one embodiment of the driving of the liquid crystal display device according to the present invention.

Fig. 12 is a plan view of the liquid crystal display device according to the present invention in a state that external circuits are connected to the liquid crystal display panel.

Fig. 13 is a flow chart showing one embodiment of a

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of Fig. 15.

of Fig. 15.

of Fig. 15.

according to the present invention.

according to the present invention.

the above-mentioned Fig. 19.

Fig. 32 is a cross-sectional view taken along a line 32-32 of Fig. 31.

Fig. 33 is a cross-sectional view taken along a line 33-33 of Fig. 31.

Fig. 34 is a cross-sectional view taken along a line 34-34 of Fig. 31.

Fig. 35 is a graph showing the characteristics of applied voltage-transmissivity of the liquid crystal display devices of the above-mentioned respective embodiments.

Fig. 36 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 37 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 38 is a cross-sectional view taken along a line 38-38 of Fig. 37.

Fig. 39 is a cross-sectional view taken along a line 39-39 of Fig. 37.

Fig. 40 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 41 is a cross-sectional view taken along a line 41-41 of Fig. 40.

Fig. 42 is an explanatory view showing another embodiment

Best Mode for Carrying out the Invention

A liquid crystal display device according to the present invention is explained in more detail in conjunction with embodiments hereinafter.

[Embodiment 1]

«Constitution of pixel»

Fig. 1 is a constitutional view of a pixel region of a liquid crystal display device (panel) according to the present invention and is a plan view as viewed from a liquid-crystal side of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner while sandwiching liquid crystal therebetween.

A cross-sectional view taken along a line 2-2 of Fig. 1 is shown in Fig. 2, a cross-sectional view taken along a line 3-3 of Fig. 1 is shown in Fig. 3, and a cross-sectional view taken along a line 4-4 in Fig. 1 is shown in Fig. 4.

First of all, in Fig. 1, gate signal lines GL which are extended in the x direction in the drawing and are arranged in parallel in the y direction in the drawing are formed of chromium (Cr), for example. Rectangular regions are formed by these gate signal lines GL and drain signal lines DL which will be explained later and these regions constitute pixel regions.

Then, in the pixel region, counter electrodes CT which generate an electric field between the counter electrodes CT and pixel electrodes PX which will be explained later are formed

on the whole area of the pixel region except for periphery thereof. The counter electrodes CT are formed of a transparent conductive bodies such as ITOl (Indium-Tin-Oxide), for example.

With respect to the counter electrodes CT, a counter voltage signal line CL which is connected to the counter electrode CT is formed such that the counter voltage signal line CL frames the whole area of a periphery of the counter electrode CT, and the counter voltage signal lines CL is integrally formed with counter voltage signal lines CL which are formed in the same manner as the counter electrode CT on the left and right pixel regions in the drawing (respective pixel regions arranged along the gate signal lines GL).

In this case, the connection of both counter voltage signal lines CL in the pixel regions is performed at an upper portions and lower portions of the pixel regions respectively. Such a connection is made to minimize portions where the counter voltage signal line CL and the drain signal line DL which will be explained later are superposed so as to reduce the capacitance generated between them.

The counter voltage signal lines CL are made of opaque material such as chromium (Cr). In such a case, an electric field which functions as a noise is generated between the drain signal line DL which will be explained later and a peripheral portion of the counter electrode CT which is disposed close to the drain signal line DL so that the light transmissivity of

the liquid crystal may not be obtained as desired. However, since such a portion is shielded from light due to the counter voltage signal line CL, a drawback in terms of display quality can be resolved.

This implies that the drawback derived from the electric field (noise) which is generated between the gate signal line GL and a peripheral portion of the counter electrode CT which is disposed close to the gate signal line GL can be also resolved.

Further, as mentioned above, by making material of the counter voltage signal line CL equal to material of the gate signal line GL, these signal lines can be formed in the same step so that the increase of man-hours for fabricating can be obviated.

Here, it is needless to say that the above-mentioned counter voltage signal lines CL are not limited to Cr and may be formed of, for example, Al or material containing Al.

However, in this case, it is more advantageous to position the counter voltage signal line CL as an upper layer with respect to the counter electrode CT. This is because that a selective etchant (for example, HBr) for an ITO film which constitutes the counter electrode CT easily resolves Al.

Further, it is advantageous to interpose metal of a high melting point such as Ti, Cr, Mo, Ta, W at least on a contact surface between the counter voltage signal line CL and the counter electrode CT. This is because that ITO which

constitutes the counter electrode CT oxidizes Al in the counter voltage signal line CL thus forming a high resistance layer.

Accordingly, in one embodiment, when the counter voltage signal lines CL are formed of Al or material containing Al, it is preferable to adopt a multi-layered structure which uses the above-mentioned metal of a high melting point as a first layer.

Then, on an upper surface of the transparent substrate on which the counter electrodes CT, the counter voltage signal lines CL and the gate signal lines GL are formed, an insulation film GI which is made of SiN, for example, is formed such that the insulation film GI covers them.

The insulation film GI functions as an interlayer insulation film of the counter voltage signal lines CL and the gate signal lines GL with respect to the drain signals DL which will be explained later, functions as a gate insulation film in regions where thin film transistors TFT which will be explained later are formed, and functions as a dielectric film in regions where capacitive elements Cstg which will be explained later are formed.

Then, the thin film transistor TFT is formed in a superposed manner on a portion (left lower portion in the drawing) of the gate signal line GL and a semiconductor layer AS which is made of a-Si, for example, is formed on the insulation film GI at the portion.

By forming a source electrode SD1 and a drain electrode

SD2 on an upper surface of the semiconductor layer AS, a MIS type transistor having an inverse stagger structure which uses a portion of the gate signal line GL as a gate electrode is formed. Here, the source electrode SD1 and the drain electrode SD2 are simultaneously formed with the drain signal line DL.

That is, the drain signal lines DL which are extended in the y direction and are arranged in parallel in the x direction in Fig. 1 are formed and portions of these drain signal lines DL are extended over the surface of the semiconductor layer AS so as to form the drain electrodes SD2 of the thin film transistors TFT.

Further, the source electrodes SD1 are formed at the time of forming the drain signal lines DL and these source electrodes SD1 are also extended to the inside of the pixel region so as to integrally form contact portions which are served for connecting the source electrodes SD1 with pixel electrodes PX which will be explained later.

Here, as shown in Fig. 3, a contact layer d0 doped with n-type impurity, for example, is formed on interfaces between the semiconductor layer AS and the above-mentioned source electrode SD1 and the drain electrode SD2.

The contact layer d0 is formed such that an n-type impurity doping layer is formed on the whole area of the surface of the semiconductor layer AS, the source electrode SD1 and the drain electrode SD2 are formed, and thereafter, using these

respective electrodes as masks, the n-type impurity doping layer formed on the surface of the semiconductor layer AS which is exposed from respective electrodes is etched.

In this embodiment, the semiconductor layer AS is formed not only on the region where the thin film transistor TFT is formed but also on portions where the gate signal lines GL and the counter voltage signal lines CL intersect the drain signal lines DL. Such a provision is made to strengthen the function of the semiconductor layer AS as the interlayer insulation film.

On the surface of the transparent substrate on which the thin film transistors TFT are formed in this manner, a protective film PSV which is made of SiN, for example, is formed such that the protective film PSV also covers the thin film transistors TFT. The protective film PSV is provided for avoiding the direct contact of the thin film transistors TFT with the liquid crystal LC.

Further, on an upper surface of the protective film PSV, pixel electrodes PX are formed using transparent conductive films made of ITO2 (Indium-Tin-Oxide), for example.

The pixel electrodes PX are superposed on the regions where the above-mentioned counter electrode CT is formed. In this embodiment, five pieces of pixel electrodes PX are formed and these pixel electrodes PX are respectively extended in the y direction while being equally spaced apart from each other, wherein these pixel electrodes PX are connected with each other

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Then, on the surface of the transparent substrate on which the pixel electrodes PX and the counter electrodes CT are formed in this manner, an orientation film ORI1 is formed such that the orientation film ORI1 also covers the pixel electrode

PX and the counter electrodes CT. The orientation film ORI1 is a film which is directly brought into contact with the liquid crystal LC and determines the initial orientation direction of the liquid crystal LC.

Although the pixel electrodes PX are constituted as transparent electrodes in the above-mentioned embodiments, the pixel electrodes PX are not always transparent and may be formed of opaque metal material such as Cr. This is because that, although the numerical aperture is slightly decreased in such a case, this gives rise to no problem at all with respect to the driving of the liquid crystal LC.

Although the case in which chromium (Cr) is used as the gate signal lines GL, the counter voltage signal lines CL and the drain signal lines DL has been explained in the above-mentioned embodiments, it is needless to say that other metal of a high melting point such as Mo, W, Ti, Ta or an alloy of two or more kinds of these metals or a lamination film of two or more kinds of these metals or alloys can be used.

Further, also with respect to the transparent conductive film, although the case which uses ITO as the transparent conductive film has been explained, it is needless to say that a similar advantageous effect can be obtained by using IZO (Indium-Zinc-Oxide).

«Filter substrate»

The transparent substrate having such a constitution is

referred to as a TFT substrate and the transparent substrate which is arranged to face the TFT substrate in an opposed manner by way of the liquid crystal LC is referred to as a filter substrate.

With respect to the filter substrate, as shown in Fig. 2, on a liquid-crystal-side surface, first of all, a black matrix BM is formed such that respective pixel regions are defined, and in opening portions of the black matrix BM which substantially define the pixel regions, filters FIL are formed such that the filters FIL cover the opening portions.

Then, an overcoat film OC which is formed of a resin film, for example, is formed such that the overcoat film OC covers the black matrix BM and the filters FIL and an orientation film ORI2 is formed on an upper surface of the overcoat film.

«Overall constitution of liquid crystal display panel»

Fig. 5 is an overall constitutional view of a liquid crystal display panel showing a display region AR which is constituted of a mass of respective pixel regions which are arranged in a matrix array.

The transparent substrate SUB2 is formed slightly smaller than the transparent substrate SUB1 and the transparent substrate SUB2 is arranged such that a right side and a lower side thereof in the drawing become substantially coplanar with corresponding sides of the transparent substrate SUB1.

Due to such a constitution, regions which are not covered

terminal DTM which is provided for supplying video signals to each drain signal line DL, wherein Fig. 8(a) is a plan view and Fig. 8(b) is a cross-sectional view taken along a line B-B of Fig. 8(a).

First of all, the drain signal terminal DTM which is formed on the transparent substrate SUB1 is constituted of the ITO film IT001 which exhibits the reliable characteristic against the electrolytic corrosion and the ITO film IT01 is simultaneously formed with the counter electrode CT.

Then, although the drain signal terminal DTM is connected with the drain signal line DL which is formed on the insulation film GI, a following drawback arises when the drain signal terminal DTM is connected with the drain signal line DL by forming the contact hole in the insulation film GI.

That is, the insulation film GI made of SiN which is formed on the ITO film becomes a whitely muddy state at a portion thereof which is brought into contact with the ITO film so that when the contact hole is formed in the portion, the contact hole is formed in an inversely-tapered shape whereby there still remains a possibility that the connection of the drain signal line DL becomes defective.

Accordingly, as shown in the drawing, a metal layer gl made of Cr, for example, is formed on an end portion of the drain signal terminal DTM in a superposed manner and the contact hole is formed on the insulation film GI formed on the metal layer

electrolytic corrosion and is simultaneously formed with the counter electrode CT.

Then, the counter voltage signal lines CL are formed such that the counter voltage signal line CL cover the counter voltage signal terminal CTM at a counter-voltage-signal-line-CL-side end portion.

Further, the insulation film GI and the protective film PSV which are formed as the extension portions in the display region AR are sequentially laminated on these signal lines so as to cover these signal lines and a portion of the counter voltage signal terminal CTM is exposed through openings formed in the protective film PSV and the insulation film GI.

«Equivalent circuit»

Fig. 10 is a view which shows an equivalent circuit of a liquid crystal display panel along with exteriorly mounted circuits of the liquid crystal display panel.

In Fig. 10, scanning signals (voltage signals) are sequentially supplied to respective gate signal lines GL which are extended in the x direction and are arranged in parallel in the y direction from a vertical scanning circuit V.

Thin film transistors TFT of respective pixel regions which are arranged along the gate signal lines GL to which the scanning signals are supplied are turned on by the scanning signals.

Video signals are supplied from a video signal driver

circuit H to respective drain signal lines DL at the timing which matches the above operation and the video signals are applied to the pixel electrodes PX through the thin film transistors of respective pixel regions.

In each pixel region, counter voltages are applied to the counter electrode CT which is formed along with the pixel electrodes PX through the counter voltage signal line CL so as to generate an electric field between them.

Then, the light transmissivity of the liquid crystal LC is controlled by an electric field (a lateral electric field) which has a component parallel to the transparent substrate SUB1 out of this electric field.

In the drawing, respective symbols R, G, B which indicate respective pixel regions imply that a red filter, a green filter and a blue filter are respectively formed on respective pixel regions.

«Timing chart of pixel display»

Fig. 11 is a timing chart of respective signals supplied to the liquid crystal display panel. In the drawing, VG indicates the scanning signal supplied to the gate signal line GL, VD indicates video signal supplied to the drain signal line DL, and VC indicates the counter voltage signal supplied to the counter voltage signal line CT.

Fig. 11 is a drive waveform diagram showing a general line inversion (a dot inversion) with the potential of the

counter voltage signal VC set at a fixed value.

«Liquid crystal display panel module»

Fig. 12 is a plan view which shows a module structure on which the exterior circuits are mounted on the liquid crystal display panel PNL shown in Fig. 5.

In the drawing, to the periphery of the liquid crystal display panel, the vertical scanning circuit V, the video signal driver circuit H and a power supply circuit board PCB2 are connected.

The vertical scanning circuit V is constituted of a plurality of driver IC chips which are formed in a film carrier system and output bumps thereof are connected to the gate signal terminals GTM of the liquid crystal display panel, while input bumps thereof are connected to terminals on a flexible substrate.

The video signal driver circuit H, in the same manner, are also constituted of a plurality of driver IC chips which are formed in a film carrier system and output bumps thereof are connected to the drain signal terminals DTM of the liquid crystal display panel, while input bumps thereof are connected to terminals on the flexible substrate.

The power supply circuit board PCB2 is connected to the video signal driver circuit H through a flat cable FC and the video signal driver circuit H is connected to the vertical scanning circuit V through a flat cable FC.

extension portions of the drain signal lines DL on the drain-signal-terminal forming region.

Step (E)

A SiN film is formed on the whole area of the surface of the transparent substrate SUB1 by a CVD method, for example, thus forming the protective film PSV. Then, the protective film PSV is selectively etched by a photolithography technique so as to form the contact hole which exposes a portion of the drain electrode SD2 of the thin film transistor TFT on the pixel region and the contact hole which penetrates the protective film PSV and reaches the insulation film GI disposed below the protective film PSV and exposes a portion of the conductive layer g1 on the drain-signal-terminal forming region.

Step (F)

An ITO film ITO2 is formed on the whole area of the surface of the transparent substrate SUB1 by a sputtering method, for example. Then, the ITO film is selectively etched by a photolithography technique so as to form the pixel electrode PX which is connectd to the drain electrode SD2 of the thin film transistor TFT through the contact hole on the pixel region and the connection layer which connects the drain signal line DL and the above-mentioned conductive layer g1 on the drain-signal-terminal forming region.

In the above-mentioned fabricating method, the step (A) and the step (B) can be reversed. That is, the counter electrode

The constitution of this embodiment which differs from the constitution of the first embodiment is that, first of all, counter electrodes CT which are formed of transparent electrodes are formed on an insulation film GI and the counter electrodes CT and the drain signal lines DL are formed on the same layer.

This implies that the counter electrodes CT are formed as layers which are different from gate signal lines GL.

Then, conductive films FGT which are formed on a side portion of the counter electrode CT at a position close to the drain signal lines DL are formed on the same layer as the gate signal lines GL, wherein the conductive films FGT are formed in the state that the conductive films FGT are not electrically connected with the counter electrodes CT.

Accordingly, as in the case of the embodiment 1, the conductive films FGT do not function as portions of the counter voltage signal lines CL and exclusively function as light shielding materials which shield the leaking of light or the like due to liquid crystal derived from an electric field generated between the drain signal lines DL and the counter electrodes CT.

Such a constitution brings about an advantageous effect that a distance between the drain signal line DL and the counter electrode CT can be narrowed so that the numerical aperture can be enhanced.

regions, it is possible to obtain an advantageous effect that it is unnecessary to specifically form the counter voltage signal lines CL shown in the embodiment 1.

Accordingly, by disposing the pixel electrodes PX closer to the gate signal lines GL or by extending the pixel electrodes PX to an extent that the pixel electrodes PX are superposed on the gate signal lines GL (see Fig. 15), it is possible to make the pixel electrodes PX have a function of the pixel region also in the vicinity of the gate signal lines GL.

This brings about an advantageous effect that, in the vicinity of the gate signal lines GL, it is sufficient to make the gate signal lines GL per se have the function of the black matrix (in other words, the black matrix which covers the gate signal lines GL and portions in the vicinity of the gate signal lines GL being no more necessary) so that the numerical aperture can be largely enhanced.

In the above-mentioned embodiment, among respective pixel regions, the counter electrodes CT of respective pixel regions which are arranged along the drain signal lines DL are commonly constituted. However, it is needless to say that the counter electrodes CT of respective pixel regions which are arranged along the gate signal lines GL are commonly constituted.

In this case, it is necessary that the counter electrodes CT are formed on the layer which is different from the layer

for the drain lines DL and it is applicable to the constitution of the embodiment 1.

«Fabricating method»

Fig. 19 and Fig. 20 are flow charts showing one embodiment of the fabricating method of the liquid crystal display device described in the above-mentioned embodiment. These drawings correspond to Fig. 13 and Fig. 14.

To compare with the embodiment 1, this embodiment differs from the embodiment 1 in the fabrication steps corresponding to the difference in constitution that the counter electrodes CT are formed on an upper surface of the insulation film GI and the pixel electrodes PX are formed on the counter electrodes CT by way of the protective film PSV.

[Embodiment 3]

Fig. 21 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and corresponds to Fig. 15. Fig. 22 is a cross-sectional view taken along a line 22-22 of Fig. 21.

In Fig. 21, symbols which are equal to the symbols in Fig. 15 indicate the equal parts.

The portion of this embodiment which differs from the constitution shown in Fig. 15 is that, first of all, in the inside of respective pixel regions which are arranged along drain signal lines DL, counter voltage signal lines CL which run substantially in parallel with the drain signal lines DL are

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Then, the counter voltage signal line CL runs at the center of the pixel region so as to divide the pixel region in substantially halves. This is because that the counter voltage signal line CL is formed such that the short-circuiting of the counter voltage signal line CL and the drain signal lines DL which are disposed at both sides of the pixel region can be surely avoided.

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In view of the fact that the portions on which the pixel electrodes PX are formed constitute portions which cannot avoid the reduction of the light transmissivity, this embodiment is provided to minimize the reduction of the light transmissivity on the whole pixel region by positioning the counter voltage signal line CL on the portion.

In this embodiment, the ITO film IT01 is formed on an upper surface of the drain signal line DL by lamination and even when the drain signal line DL is formed in a disconnected state, the disconnection can be repaired by the ITO film IT01.

Since the ITO film IT01 can be simultaneously formed at the time of forming the counter electrode CT, it is possible to obtain an advantageous effect that the increase of man-hours for fabrication can be avoided.

[Embodiment 4]

Fig. 23 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and Fig. 24, Fig. 25 and Fig. 26 are respectively a cross-sectional view taken along a line 24-24 of Fig. 23, a cross-sectional view taken along a line 25-25 of Fig. 23 and a cross-sectional view taken along a line 26-26 of Fig. 23.

Fig. 23 is a view which corresponds to Fig. 1, wherein symbols which are equal to the symbols in Fig. 1 indicate the equal parts.

The constitution of Fig. 23 which differs from the

equal to the symbols in Fig. 1 indicate the equal parts.

In Fig. 27, the constitution of this embodiment which differs from the constitution shown in Fig. 1 is that, first of all, pixel electrodes PX are positioned as lower layers and counter electrodes CT are positioned as upper layers by way of an insulation layer.

As shown in Fig. 28, a first protective film PSV1 is formed on an upper surface of an insulation film GI and the pixel electrode PX is formed on the first protective film PSV1.

The pixel electrode PX is constituted of a transparent electrode which is formed on a major portion excluding a periphery of the pixel region, wherein the pixel electrode PX is connected with a source electrode SD2 of a thin film transistor TFT which is formed as a layer below the first protective film PSV1 through a contact hole.

Then, a second protective film PSV2 is formed such that the second protective film PSV2 also covers the pixel electrode PX in such a manner and the counter electrode CT is formed on an upper surface of the second protective film PSV2.

The counter electrodes CT is formed of a plurality of strip-like electrodes which are extended in the y direction and are arranged in parallel in the x direction in the drawing in a region where the counter electrode CT is superposed on the pixel electrode PX. These electrodes are formed such that the electrodes have respective both ends thereof connected with

the first protective film PSV1, it is proper to use an organic film having a relative dielectric constant of 3 to 4 and a film thickness of 1000 to 3000 nm as the second protective film PSV2.

Further, when the relative dielectric constant of the second protective film PSV2 is set to equal to or less than 1/2 of the relative dielectric constant of the first protective film PSV1, it has been confirmed that no defects appear in practical products irrespective of the film thickness. Still further, when the film thickness of the second protective film PSV2 is set to twice or more of the film thickness of the first protective film PSV1, it has been confirmed that no defects appear in practical products irrespective of the relative dielectric constant.

[Embodiment 6]

Fig. 31 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and Fig. 32 is a cross-sectional view taken along a line 32-32 of Fig. 31.

Fig. 31 shows a further improved constitution compared to the constitution of the embodiment 5 and symbols which are as same as the symbols used in Fig. 27 to Fig. 30 indicate identical materials.

The constitution which makes the embodiment 6 differ from the embodiment 5 is that, first of all, pixel electrodes PX are formed on an insulation film GI and counter electrodes CT are

[illegible]

The above-mentioned characteristics are those of elements which are prepared by using liquid crystal material having mainly negative dielectric anisotropy. On the other hand, when the liquid crystal material having positive dielectric anisotropy is used, although the maximum values of transmissivity of respective embodiments were decreased by 0.5 % respectively, an advantageous effect that a threshold value voltage is reduced by 0.5 V was obtained to the contrary.

[Embodiment 7]

Here, with respect to the multi-domain system, in an electric field (a lateral electric field) which is generated in the spreading direction of the liquid crystal, regions which

field which is generated between the counter electrode CT and the pixel electrode PX at bent portions of the pixel electrodes PX is generated exactly in the same manner between the counter electrodes CT and the pixel electrode PX at other portions of the pixel electrodes PX. Conventionally, a so-called disclination region which defines a non-transmitting portion where the twisting directions of molecules of the liquid crystal become random was generated.

Accordingly, it is possible to obtain an advantageous effect that a drawback that the light transmissivity is decreased in the vicinity of bent portions of the pixel electrodes PX can be obviated.

Here, although the pixel electrodes PX are formed by extending them in the y direction as shown in Fig. 36 in this embodiment, the pixel electrodes PX may be extended in the x direction in the drawing and bent portions are provided to these pixel electrodes PX so as to obtain the advantageous effect of the multi-domain system. Further, in this embodiment, the advantageous effect of the multi-domain system is obtained by providing the bent portions to the pixel electrodes PX.

However, in the constitution that the pixel electrodes PX are formed at least on the whole area of the pixel region except for the periphery of the pixel region and, as shown in Fig. 28, for example, the counter electrodes CT are extended in one direction and are arranged in parallel in the direction

which intersects one direction, it is needless to say that bent portions are provided to the counter electrodes so as to obtain the advantageous effect of the multi-domain system.

[Embodiment 8]

Fig. 37 is a plan view showing another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 27.

Here, in Fig. 37, a cross-sectional view taken along a line 38-38 and a cross-sectional view taken along a line 39-39 are respectively shown as Fig. 38 and Fig. 39. Parts which are indicated by symbols equal to the symbols used in Fig. 27 are constituted of the identical materials. The difference in constitution compared to Fig. 27 lies in the pixel electrodes PX.

The pixel electrode PX is constituted such that apertures are formed in portions which are superposed on the counter electrode CT while excluding a peripheral portion thereof. Accordingly, center axes of the counter electrodes CT extending in one direction are substantially aligned with center axes of the openings of the above-mentioned pixel electrode PX, wherein assuming a width of the counter electrode CT as W, a width of the opening is set to LL which is smaller than the width W.

In such a constitution, the distribution of the electric field which is generated between the pixel electrode PX and the counter electrodes CT can be generated exactly in the same

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

100

As mentioned above, although the capacitance between the pixel electrode PX and the counter electrodes CT is necessary to some extent to store video signals supplied to the pixel electrode PX for a relatively long time, when the capacitance is excessively increased, the brightness irregularities of display derived from the delay of signals is generated. Accordingly, by making the above-mentioned openings have a suitable size, the capacitance can be set to an optimum value.

Here, in setting the value of capacitance generated between the pixel electrode PX and the counter electrodes CT due to the openings formed in the pixel electrode PX, there may be a case that a given capacitance value cannot be obtained due to the displacement of the counter electrodes CT relative to the pixel electrode PX.

In this case, as shown in Fig. 42, for example, a pair of side portions of the opening of the pixel electrode PX (in the drawing, the sides which are parallel in the y direction in the drawing being adopted in view of the remarkable appearance of the drawback caused by the displacement) are formed in a zigzag shape, for example, so that the opening having

crest portions (projecting portions) and valley portions (recessed portions) at respective sides is formed.

When the pixel electrode PX and the counter electrode CT are arranged without the displacement as shown in Fig. 42 (a), the value of the capacitance is determined by an area on which they are superposed.

Then, even when the counter electrode CT is displaced in the x direction with respect to the pixel electrode PX as shown in Fig. 42 (b), such a superposed area is not changed so that the value of capacitance is not changed.

This is because that the relationship that when the crest portions of one side are retracted, the crest portions of the other side are projected is established.

From the above, the pattern of the opening is not limited to the above-mentioned pattern. For example, with respect to the displacement of one electrode, projecting portions which are projected towards the electrode side are formed on one of sides of the opening which intersect the direction of displacement and projecting portions which are retracted with respect to the electrode are formed on the other side of the opening.

Such a constitution does not assume the constitution of Fig. 27 as a premise thereof, and is applicable to all of the above-mentioned respective embodiments. For example, in the constitution where the counter electrodes CT are formed on the

[illegible]

[Embodiment 10]

the present invention.

5.

embodiment 1 lies in that, first of all, a protective insulation

the insulation film PSV2 is machined in a self-aligned manner with the counter electrode CT so that the display irregularities are extremely hardly generated.

As can be clearly understood from the explanation with reference to the embodiments 1 to 10, according to the liquid crystal display device of the present invention, the liquid crystal display device of extremely high performance can be obtained.

[Embodiment 11]

Fig. 44 is a constitutional view of a pixel region of another embodiment of the liquid crystal display device according to the present invention and is a plan view obtained by viewing one transparent substrate of a pair of transparent substrates which are arranged to face each other from the liquid crystal side by interposing liquid crystal between them. Further, Fig. 45 is a view showing a cross section taken along a line 45-45 of Fig. 44.

First of all, in Fig. 44, gate signal lines GL which are extended in the x direction and are arranged in parallel in the y direction in the drawing are formed on the transparent substrate SUB1 using chromium (Cr), for example. The gate signal lines GL form rectangular regions together with drain signal lines DL which will be explained later and these regions constitute pixel regions.

In the pixel region, along with the gate signal line GL,

Further, over the whole area of a central portion of the

transparent substrate SUB1 such that the insulation film GI also covers the gate signal lines GL, the counter voltage signal lines CL and the counter electrodes CT. The insulation film GI is configured to perform a function of an interlayer insulation film between the counter voltage signal lines CL and the gate signal lines GL with respect to the drain signal line DL which will be explained later, to perform a function of a gate insulation film of thin film transistors TFT which will be described later in regions where the thin film transistors TFT are formed, and to perform a function of a dielectric film in regions in which capacitive elements Cstg which will be described later are formed.

As shown at a left lower portion of Fig. 44, on the above-mentioned insulation film GI at a portion of the thin film transistor TFT which is partially superposed on the gate signal line GL, a semiconductor layer AS made of a-Si, for example, is formed.

By forming a source electrode SD2 and a drain electrode SD1 on an upper surface of the semiconductor layer AS, an MIS-type transistor of an inverse stagger structure which uses a portion of the gate signal line GL as the gate electrode is formed. Then, the source electrode SD2 and the drain electrode SD1 are formed simultaneously with the drain signal line DL.

That is, the drain signal lines DL which are extended in the y direction and are arranged in parallel in the x direction

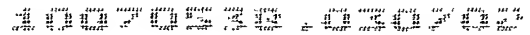
in Fig. 44 are formed and a portion of the drain signal line DL is extended over a surface of the above-mentioned semiconductor layer AS so as to constitute the drain electrode SD1 of the thin film transistor TFT.

Further, at the time of forming the drain signal lines DL, the source electrodes SD2 are formed and these source electrodes SD2 are extended over portions in the inside of the pixel regions so that contact portions which connect the source electrodes SD2 and the pixel electrodes PX which will be explained later are integrally formed with the source electrodes SD2.

Here, on an interface between the above-mentioned source electrode SD2 and drain electrode SD1 of the semiconductor layer AS, contact layers d0 which are doped with n-type impurity, for example, is formed.

The contact layers d0 are formed such that an n-type impurity doping layer is formed on the whole area of the surface of the semiconductor layer AS, the source electrode SD2 and the drain electrode SD1 are formed and, thereafter, by using the respective electrodes as masks, the n-type impurity doping layer on the surface of the semiconductor layer AS which is exposed from these respective electrodes is etched.

Here, in this embodiment, the semiconductor layers AS are formed not only in the regions where the thin film transistors TET are formed but also at portions where the gate



Then, on the surface of the transparent substrate SUB1 on which the thin film transistors TFT are formed, a protective film PSV made of SiN, for example, is formed such that the protective film PSV also covers the thin film transistors TFT. The protective film PSV is provided for avoiding the direct contact of the thin film transistors TFT with the liquid crystal LC.

Further, on an upper surface of the protective film PSV, pixel electrodes PX which are formed of transparent conductive films made of ITO (Indium-Tin-Oxide), for example, are formed.

Then, the pixel electrode PX has a portion thereof connected to an extension portion of the source electrode SD2 of the thin film transistor TFT through a contact hole formed in the above-mentioned protective film PSV.

The pixel electrode PX is constituted of a plurality of first electrodes PX' having bent portions on the counter voltage signal line CL' which is extended in the y direction in the drawing at the substantially central portion of the pixel region and a frame-like second electrode PX'' which respectively connects respective ends of these first electrodes PX'. In

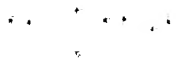
signal line CL' which is extended in the y direction at the center of the pixel region out of the above-mentioned counter voltage signal line CL.

In the vicinity of bent portions of the first electrodes PX', the directions of the electric fields become random so that an opaque region (hereinafter this region being referred to as "disclination region") to which a strict lateral electric field is not applied is generated. Accordingly, this embodiment adopts the constitution which shields the region from light by using the signal line CL'.

Further, with respect to the above-mentioned first electrode PX', an opening angle of electrodes with respect to the bent portions as the center is set to 2θ ($< 90^\circ$) and hence, the opening angle assumes an acute angle.

In such a case, a relatively strong electric field is liable to be generated between the first electrodes PX' and the counter electrode CT at these bent portions so the liquid crystal molecules are rotated at a high speed. Accordingly, using these bent portions as starting points, the high-speeding of the rotation of the liquid crystal molecules can be propagated to peripheries of the bent portions and further to the whole area of the pixel region whereby it is possible to obtain an advantageous effect that a display which can promote the rapid response is achieved.

Further, out of the pixel electrodes PX, the second



electrode PX" is constituted of a frame-like electrode PX" which is superposed on the inner peripheral portion of the signal line CL" which is formed in a frame-like shape out of the above-mentioned counter voltage signal line CL. The second electrode PX" is connected with extension ends of the above-mentioned first electrodes PX'.

Between portions of the second electrode PX" extending in the y direction in Fig. 44 and the drain signal lines DL which are disposed adjacent to these portions, the above-mentioned counter voltage signal lines CL" are formed such that they are extended in the y direction in the drawing.

The counter voltage signal lines CL" are formed with a wide width such that gaps between the drain signal lines DL and the counter voltage signal lines CL" can be made as small as possible.

In other words, gaps formed between the electrodes PX" which are extended in the y direction in Fig. 44 out of the pixel electrodes PX and the drain signal lines DL which are disposed adjacent to the electrodes PX" are shielded from light by means of the counter voltage signal lines CL".

Such a constitution is adopted due to following reasons. That is, an electric field is generated from the drain signal line DL in response to video signals which are supplied to the drain signal line DL. This electric field is terminated at the counter voltage signal line CL" side and the light transmission

due to the change of the light transmissivity of liquid crystal which is changed by the electric field is shielded.

The pixel electrodes PX having such a constitution can achieve following various advantageous effects.

First of all, since the regions which differ in the directions of electric fields generated between the pixel electrodes PX and the counter electrodes CT are formed by dividing the pixel region in halves, each pixel electrode PX (first pixel electrode PX') has one bent portion so that the total number of bent portions become the number of the first pixel electrodes PX'.

In a conventional liquid crystal display device, for example, respective pixel electrodes which are extended in the y direction and are arranged in parallel in the x direction in Fig. 44 are inclined in the right side along the longitudinal direction and then are inclined in the left side along the longitudinal direction and these inclinations are repeated to form the pixel electrodes in the zigzag shape. Compared to such a conventional liquid crystal display device, this embodiment can provide the constitution which largely reduces the bent portions of the electrodes.

Accordingly, it is possible to largely reduce the generation of the disclination region at the bent portions of the electrodes PX'.

Further, by newly providing the second electrode PX"

film transistor TFT) portion in the drawing out of the portions extending in the x direction in parallel in the drawing is not particularly formed, it is possible to obtain a sufficient advantageous effect. On the surface of the transparent substrate SUB1 on which the pixel electrodes PX are formed in this manner, an orientation film (not shown in Fig. 44 and Fig. 45, see embodiment 1) is formed such that the orientation film also covers the pixel electrode PX. This orientation film is a film which is subjected to the rubbing treatment in the y direction in the drawing and is brought into direct contact with a liquid crystal LC so that the orientation film can determine the initial orientation direction of the liquid crystal LC.

Although the pixel electrodes PX are constituted as the transparent electrodes in the above-mentioned embodiment, the pixel electrodes PX are not always transparent and may be formed of opaque metal material such as Cr, for example. This is because that although the numerical aperture is slightly decreased due to such a constitution, this gives rise to no defects in driving of the liquid crystal LC.

Further, the transparent substrate SUB1 having such a constitution is referred to as a so-called TFT substrate and the transparent substrate which is arranged to face this TFT substrate in an opposed manner while sandwiching the liquid crystal LC therebetween is referred to as a filter substrate. On a liquid-crystal-side surface of the filter substrate, first

of all, a black matrix is formed so as to define respective pixel regions and filters are formed such that the filters cover opening portions of the black matrix which substantially determine the pixel regions. Then, an overcoat film made of a resin film, for example, is formed such that the overcoat film covers the black matrix and the filters, and an orientation film is formed on an upper surface of the overcoat film. The detail of these components are exactly as same as those described in the embodiment 1.

[Embodiment 12]

Fig. 46 is a view which shows another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 1. Further, Fig. 47 is a view which shows a cross-section taken along a line 47-47 in Fig. 46.

The constitution of this embodiment which differs from the constitution shown in Fig. 44 is that, first of all, as a member which shields portions in the vicinity of bent portions of pixel electrodes PX having the bent portions from light, a conductive layer CL which is formed along with drain signal lines GL is used (accordingly, the conductive layer CL uses the same material as the signal lines).

The conductive layer CL constitutes a counter voltage signal line LC and hence, a counter electrode CT which is constituted of a transparent electrode is formed in an

[illegible]

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[Embodiment 13]

Fig. 48 is a view which shows another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 44.

The difference in constitution between this embodiment and the embodiment shown in Fig. 44 lies in the constitution of pixel electrodes PX, wherein in place of portions of a frame-like second electrode PX" to which respective end portions of a plurality of first electrodes PX' having bent portions are respectively connected and are extended in the y direction in the drawing, a third electrode PX3 which is extended in the y direction in the drawing at the center portion of the pixel electrode is provided.

Even when the liquid crystal display device is constituted in such a manner, it is possible to form the pixel electrodes over the whole area of the pixel region without dead spaces.

[Embodiment 14]

Fig. 49 is a view showing another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 44.

The constitution of this embodiment which differs from the constitution of Fig. 44 lies in that the pixel region is divided in halves into regions which differ in the direction of electric field by a boundary which is parallel to the x direction in the drawing.

Accordingly, this embodiment adopts a pattern in which pixel electrodes PX (first electrodes PX') having bent portions are arranged with an angle of $(-\phi: \phi > 45^\circ)$ with respect to the x direction in the drawing in one pixel region and the pixel electrodes PX are arranged with an angle of $(+\phi: \phi > 45^\circ)$ with respect to the x direction in the drawing in the other pixel region, and the corresponding pixel electrodes are connected each other at the boundary portion.

Even in such a case, it is possible to narrow dead spaces and to decrease the number of the bent portions of the first electrodes PX' of the pixel electrodes.

Further, in such a case, in view of the optimum setting of the initial orientation direction (the y direction in the drawing) of an orientation film and the directions of respective electric fields, an opening angle (2ϕ) at the bent portions of the first electrodes can be set to an obtuse angle.

Accordingly, it is possible to decrease the generation of so-called disclination regions at the bent portions of the pixel electrodes (first electrodes).

As described above, in this embodiment, although light shielding means are not provided to the bent portions of respective pixel electrodes, it is needless to say that light shielding means may be provided to achieve the complete prevention of generation of the disclination regions.

Here, it is needless to say that, in Fig. 49, with respect to the second electrode PX'', even when the upper side (the side opposite to the thin film transistor TFT) portion in the drawing among portions which are positioned parallel to the x direction in the drawing is not particularly formed, a sufficient advantageous effect can be obtained.

[Embodiment 15]

Fig. 50 is a view showing another embodiment of the liquid crystal display device according to the present invention and constitutes a view corresponding to Fig. 44.

The difference of this embodiment from the embodiment of Fig. 44 in constitution lies in the connection of a counter voltage signal line CL and the counter electrode CT. In this embodiment, gate signal lines GL use chromium (Cr) based alloy, wherein after forming the gate signal lines GL on a substrate by patterning, the counter electrodes CT (ITO1) are formed before forming a gate insulation film GI made of SiNx. For

example, in Fig. 13, the step (B) comes before the step (A) (the order of the step (A) and the step (B) is reversed). ITO films which constitute the counter electrodes CT are directly brought into contact with Cr films which constitute the counter voltage signal lines CL at the centers of the pixels defined by openings of the black matrix BM (profiles thereof being indicated by broken lines).

In Fig. 50, the applying direction of an electric field which rotatably drives liquid crystal molecules for modulating the light transmissivity of a liquid crystal layer, the direction of the electric field which is leaked from a drain signal line (also referred to as a video signal line, a data line) to the above-mentioned pixel (the region surrounded by a frame indicated by a broken line BM), and the advancing direction of a rubbing roller (so-called rubbing direction) at the time of performing the rubbing treatment on an orientation film (not shown in the drawing) which covers the illustrated electrode structure are respectively indicated by arrows of bold lines.

In this embodiment, the electric field which rotatably drives the liquid crystal molecules is applied in the up-and-down direction of the drawing (the extension direction of the drain signal line DL).

Accordingly, the influence which the electric field (lines of electric force) which is leaked from the drain signal

line to the pixel in the left-and-right direction in the drawing given to the rotation driving of the liquid crystal molecules is reduced so that the degradation of the image quality derived from longitudinal smear can be suppressed. The larger an angle which is formed by the intersection of the direction of the electric field which rotatably drives the liquid crystal molecules (arrow of "electric field applying direction to the liquid crystal") and the direction of the electric field which is leaked from the drain signal line DL to the pixel (arrow indicating "electric field direction from the drain line"), the above-mentioned generation of longitudinal smear can be suppressed more efficiently. When this intersecting angle is small, it is necessary to shield the leaking of the electric field from the drain signal line DL to the pixel by providing a counter electrode CT or a pixel electrode PX along the drain signal line DL between the drain signal line DL and the pixel. However, in this embodiment, since the pixel electrodes PX (IT02) which are arranged in a comb shape are arranged to intersect the drain line with a sufficiently large angle, such a shielding structure is unnecessary. This feature is observed at a left upper portion and a right lower portion of the pixel shown in Fig. 50 and is served for increasing the aperture ratio of the pixel per se (area which can transmit light modulated by the rotation driving of the liquid crystal molecules).

Further, according to this embodiment, it is possible

to increase the degree of freedom of designing of the electrode structure which is constituted of the other transparent conductive film IT02 (also referred to as "upper ITO layer" in view of the cross-sectional structure thereof) which is formed apart from one transparent conductive film IT01 as viewed from a main surface of the substrate. Accordingly, it is possible to design the whole pixel such that the voltage signals supplied from the drain signal line DL can be applied to the pixel electrodes PX along the line which intersects (preferably intersecting at a right angle) the extension direction of the drain signal line DL.

In this embodiment, since the extension direction of combs of the pixel electrodes PX does not intersect the drain signal line DL at a right angle, the rubbing direction (the liquid crystal molecules which are in the state that the electric field is not applied to the liquid crystal modules being oriented in the direction along this direction) can be set in the direction which intersects the drain signal line at a right angle.

In the above-mentioned embodiments 11 to 14, the counter electrode CT is formed such that the counter electrode CT is extended over the whole area of the central portion of the pixel region except for the trivial periphery of the pixel region.

However, even when the counter electrode CT is not formed at portions which are superposed on the pixel electrodes PX,

this does not give any influence to the operation of the liquid crystal. Accordingly, it is needless to say that the counter electrode CT can be formed in this manner.

Further, in the above-mentioned respective embodiments, the transparent electrode which is formed over the whole area of the central portion of the pixel region except for the trivial periphery of the pixel region is formed as the counter electrode CT and the electrodes provided with the bent portions are formed as the pixel electrodes PX. However, the present invention is not limited to such a constitution. That is, it is needless to say that the transparent electrode which is extended over the whole area of the central portion of the pixel electrode except for the trivial periphery of the pixel region is formed as the pixel electrode PX and the electrodes provided with the bent portions are formed as the counter electrodes CT.

As can be clearly understood from the explanation which has been made with reference to the embodiments 11 to 14, according to the liquid crystal display device of this embodiment, the display of images having an excellent quality can be realized.

Claims

1. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on each pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, an electric field having a component parallel to said transparent substrates is generated between these respective electrodes, one electrode out of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around the other electrode and is not superposed on the other electrode, and said insulation film has a multi-layered structure.

2. A liquid crystal display device according to claim 1, wherein said liquid crystal display device includes thin film transistors which are driven by the supply of scanning signals and supplies video signals to said pixel electrodes by said driving, and

said insulation film is formed of a sequential laminated body which comprises an insulation film which constitutes a portion of a gate insulation film of said thin film transistor and a protective film which avoids a direct contact of said thin film transistor with liquid crystal.

3. A liquid crystal display device according to claim

1, wherein one electrode out of said pixel electrode and said counter electrode is formed at least in a region of said pixel region except for a periphery of said pixel region, and the other electrode is formed of a plurality of electrodes which are extended in one direction in a superposed manner on said one electrode and are arranged in the direction which intersects said one direction.

4. A liquid crystal display device being characterized
in that

to each liquid-crystal-side pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal,

a thin film transistor which is driven by the supply of scanning signals from a gate signal line, a pixel electrode to which video signals from a drain signal line are supplied through said thin film transistor, and a counter electrode which generates an electric field containing a component along a surface of said transparent substrate between said counter electrode and said pixel electrode are provided,

said pixel electrode and said counter electrode are formed such that an insulation film is interposed between said electrodes, and at least one of said electrodes is constituted of a transparent electrode formed on a region which is disposed around the other electrode and is not superposed on at least

said one electrode, and

said insulation film is constituted of a sequential laminated body which comprises a first insulation film which functions as a gate insulation film of said thin film transistor and a second insulation film which determines a capacitance value between said pixel electrode and said counter electrode along with said first insulation film.

5. A liquid crystal display device according to claim 4, wherein said gate insulation film is constituted of a laminated structure which is made of SiO_2 mounted on said counter electrode and SiN which is formed on said SiO_2 .

6. A liquid crystal display device being characterized in that, on a liquid-crystal-side surface of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, a signal line is formed between respective pixel regions which are disposed close to each other,

in said each pixel region, one electrode out of a pair of electrodes which differ in layer is provided with an electrode forming region on which a transparent electrode formed in a region which is disposed around the other electrode and not superposed on at least said one electrode is arranged, and

within a periphery of said electrode forming region, on a side portion which is disposed close to said signal line, a

10. A liquid crystal display device in which each pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal includes a switching element, a pixel electrode and a counter electrode, and

an electric field is generated between said pixel electrode and said counter electrode by applying video signals from a drain signal line to said pixel electrode by way of said switching element, wherein

the improvement being characterized in that said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed, and is constituted of a transparent electrode formed on a region which is disposed around said pixel electrode and is not superposed on at least said pixel electrode,

on a side portion disposed close to said drain signal line, a light shielding conductive layer which is connected to said side portion is formed, and

said conductive layer constitutes a portion of a counter voltage signal line which supplies counter voltage signals to a counter electrode of a neighboring pixel region.

11. A liquid crystal display device in which each pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other

in an opposed manner by way of liquid crystal includes a switching element, a pixel electrode and a counter electrode, and

an electric field is generated between said pixel electrode and said counter electrode by applying video signals from a drain signal line to said pixel electrode by way of said switching element, wherein

the improvement being characterized in that said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed, and is constituted of a transparent electrode formed on a region which is disposed around said pixel electrode and is not superposed on at least said pixel electrode, and

a conductive layer which is made of Al or material containing Al is superposed on a side portion of said counter electrode as a lower layer disposed close to said drain signal line by way of a metal layer of a high melting point.

13. A liquid crystal display device being characterized in that said liquid crystal display device includes a signal terminal and a signal line with an insulation film disposed therebetween, wherein said signal terminal is constituted of

a first transparent metal layer and is formed as a layer below an insulation film and said signal line is formed as a layer above said insulation film,

a first metal layer other than a transparent metal layer is formed on a portion of said signal terminal in a superposed manner, and an electrical connection between said signal terminal and said signal line is established through a contact hole formed in said insulation film which exposes a portion of said first metal layer.

14. A liquid crystal display device according to claim 13, wherein a protective film is formed on said insulation film such that said protective film covers said signal line, and a second transparent metal layer which is served for connecting said first metal layer and said signal line through a contact hole which exposes a portion of said first metal layer and a contact hole which exposes a portion of said signal line is formed on said protective film.

15. A liquid crystal display device according to claim 14, wherein said first metal layer is made of Al or material containing Al and has a multi-layered structure which provides a metal layer of a high melting point on portions of upper and lower surfaces of said first metal layer which are at least respectively connected to said first transparent metal layer and said second transparent metal layer.

16. A liquid crystal display device being characterized

17. A liquid crystal display device according to claim 16, wherein counter voltage signals are supplied to said respective counter electrodes which are connected in common from the outside of a display region which is a mass of said respective pixel regions.

18. A liquid crystal display device being characterized in that each pixel region which is formed on liquid-crystal-side surfaces of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal includes a pixel electrode and a counter electrode which generate an electric field containing a component parallel to said transparent substrates,

said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed and is constituted of a transparent conductive layer formed in a region which is disposed around said pixel electrode and is not superposed on said pixel electrode,

said each pixel region includes a counter voltage signal line which runs at the approximately center of each of said pixel regions arranged in parallel in one direction and is formed in an superposed manner on said counter electrode, and

said counter voltage signal line is made of material having smaller resistance than said counter electrode.

19. A liquid crystal display device according to claim 18, wherein said pixel electrode is constituted of a plurality

of transparent substrates which are arranged to face each other by way of said liquid crystal,

a pixel electrode and a counter electrode which are arranged by way of a first insulation film and generate an electric field which is extended in a spreading direction of said liquid crystal are provided in the inside of said pixel region, and

a second insulation film which has openings formed in portions of said pixel region and covers at least one of said gate signal line and said drain signal line is formed on said first insulation film and a conductive layer is formed on a surface of said second insulation film.

29. A liquid crystal display device according to claim 28, wherein said second insulation film has a relative dielectric constant which is equal to or less than $1/2$ of a relative dielectric constant of said first insulation film or a film thickness of said second insulation film is twice or more larger than a film thickness of said first insulation film.

30. A liquid crystal display device according to claim 28, wherein said conductive film is integrally formed with either one of said pixel electrode and said counter electrode and said electrodes are formed by forming openings in said conductive film which is formed on the whole area of a display region which is a mass of said pixel region.

31. A liquid crystal display device characterized in that

a pair of electrodes which generate an electric field in a spreading direction of liquid crystal are formed on each pixel region on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of said liquid crystal,

a pair of said electrodes are formed in different layers and said one electrode is formed of a transparent electrode formed in a region which is disposed around said other electrode and is not superposed on at least said one electrode, and

said other electrode is formed in a pattern which constitutes a region which makes the direction of an electric field which is generated between said other electrode and said one electrode different.

32. A liquid crystal display device characterized in that a pair of electrodes which generate an electric field in a spreading direction of liquid crystal are formed on each pixel region on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of said liquid crystal,

a pair of said electrodes are formed in different layers and said one electrode is formed of a transparent electrode formed in a region which is disposed around said other electrode and is not superposed on at least said one electrode, and

said other electrode is formed in a zigzag shape by repeating the extending of said other electrode while inclining the other electrode by an angle θ with respect to one direction and the subsequent extending of said other electrode while bending the other electrode by an angle of (-2θ) .

33. A liquid crystal display device characterized in that a pair of electrodes which generate an electric field which is parallel to said transparent substrate are formed on each liquid-crystal-side pixel region of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal,

a pair of said electrodes are formed in different layers, out of a pair of said electrodes, one electrode is constituted of a plurality of electrodes which are extended in one direction and are arranged in parallel in the direction which intersects said one direction, and

said other electrode is formed of a transparent electrode which has openings at regions which are superposed on said one electrode and is formed on at least regions excluding a periphery of said pixel region.

34. A liquid crystal display device according to claim 33, wherein a periphery in which openings of said other electrode are formed is superposed on said one electrode.

35. A liquid crystal display device according to claim 33, wherein said openings of said other electrode are formed

in that, on a liquid-crystal-side rectangular pixel region of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed, and an electric field containing a component parallel to said transparent substrates is generated between said respective electrodes,

said one electrode out of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode is constituted of a plurality of electrodes which are arranged in parallel in the direction which intersects the extension direction of said other electrode at a right angle, said electrodes including bent portions which change said extending direction, and electrodes which are extended linearly at least at portions of a periphery of said pixel region.

45. A liquid crystal display device according to claim 44, said other electrodes which are extended linearly at least portions of said periphery of said pixel region are connected with said other electrodes having bent portions which change said extending direction.

46. A liquid crystal display device according to claim

45, wherein said electrodes which are extended linearly at least at said portions of said periphery of said pixel region have a function of supplying video signals to said electrodes having said bent portions.

47. A liquid crystal display device according to claim 45 or 46, wherein said other electrodes which are extended linearly at said periphery of said pixel region is formed in a frame shape.

48. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on a rectangular pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and an electric field having a component parallel to said transparent substrates is generated between these electrodes,

one of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode comprises a plurality of electrodes which are arranged in parallel in the direction perpendicular to an extension direction of said pixel electrode, wherein a plurality of electrodes consist of first electrodes having bent portions which change the extension direction and second

orientation direction of said liquid crystal, and an opening angle of said bent portions of said other electrodes having bent portions are set to an obtuse angle.

52. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on each pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and an electric field having a component parallel to said transparent substrates is generated between these electrodes,

one of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode includes bent portions which change the extension direction and light-shielding members are formed on said bent portions by way of an insulation film.

53. A liquid crystal display device according to claim 52, wherein said other electrode is constituted of a plurality of electrodes which are arranged in parallel in the direction which intersects the extension direction of said other electrode, bent portions of said respective electrodes are positioned on an imaginary line which transverses substantially the center of said pixel region, and a light-shielding member

100

FIG. 1

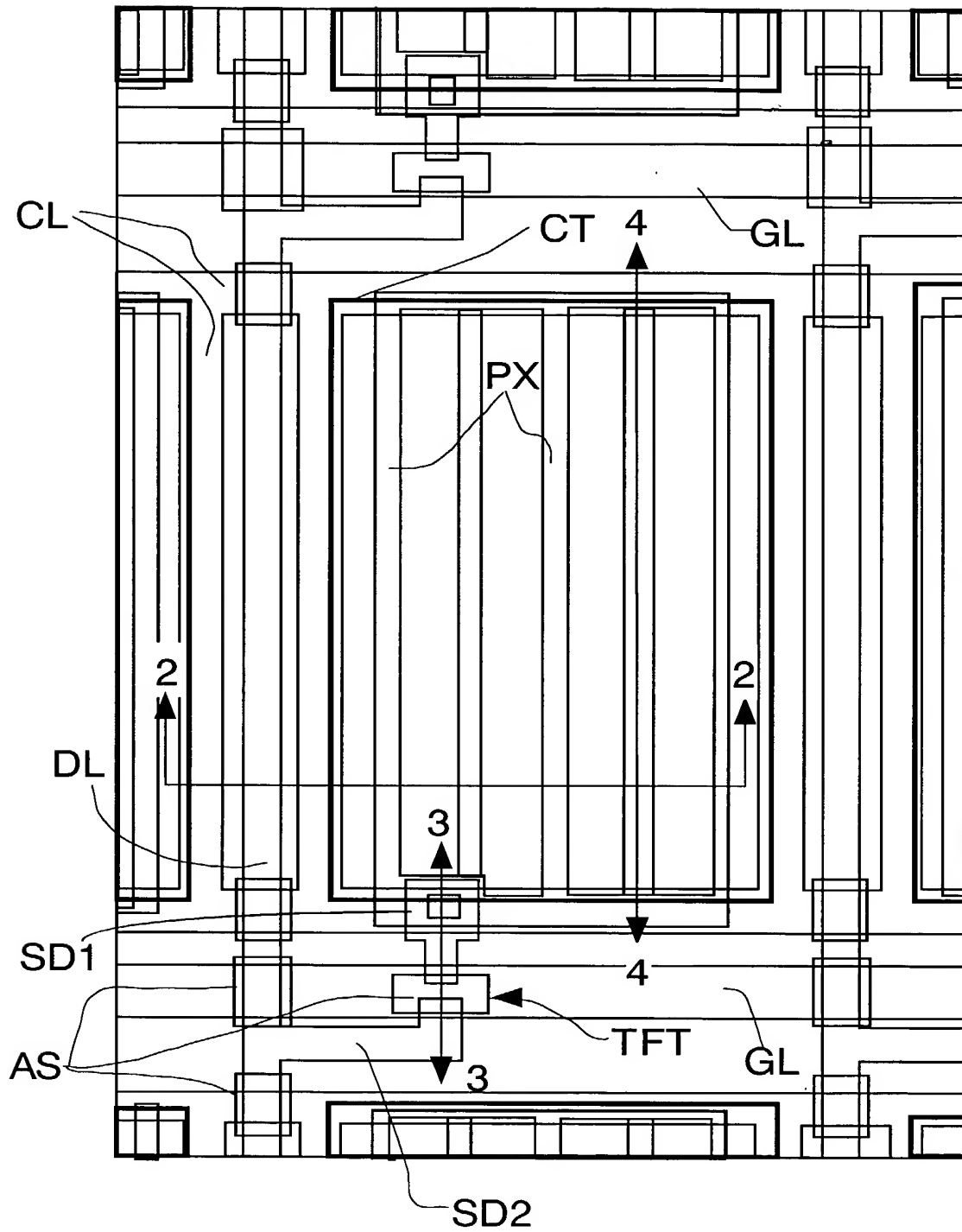


FIG. 2

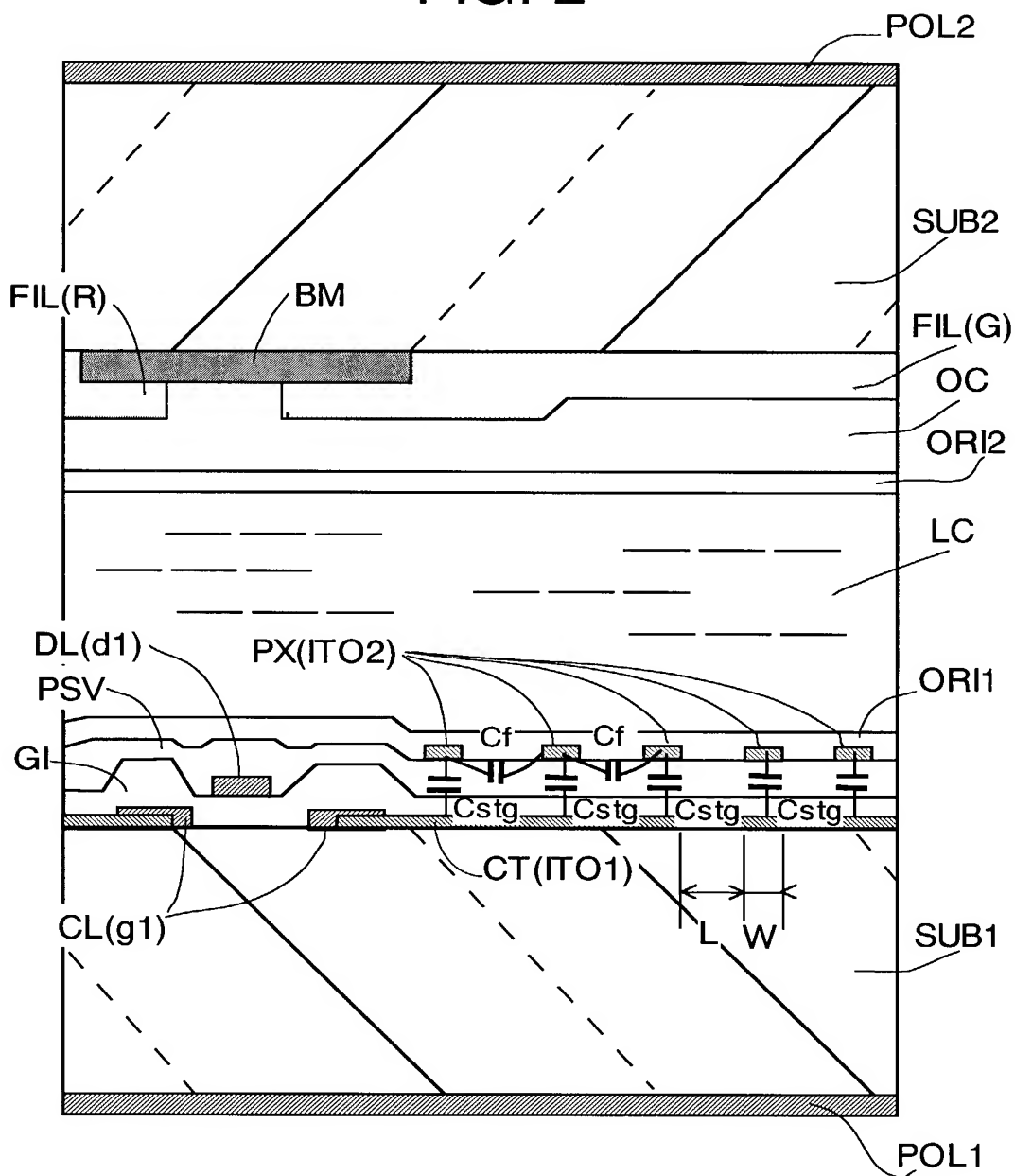


FIG. 4

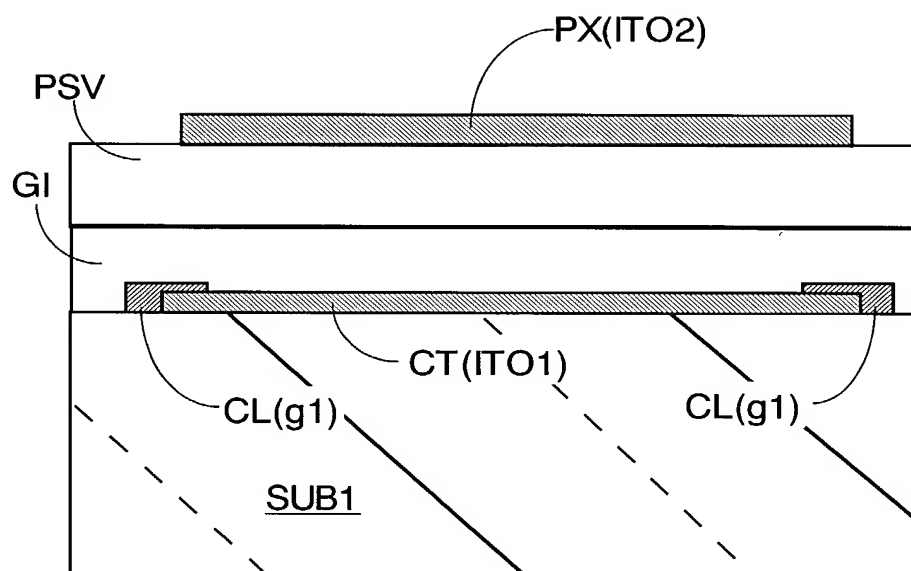


FIG. 5

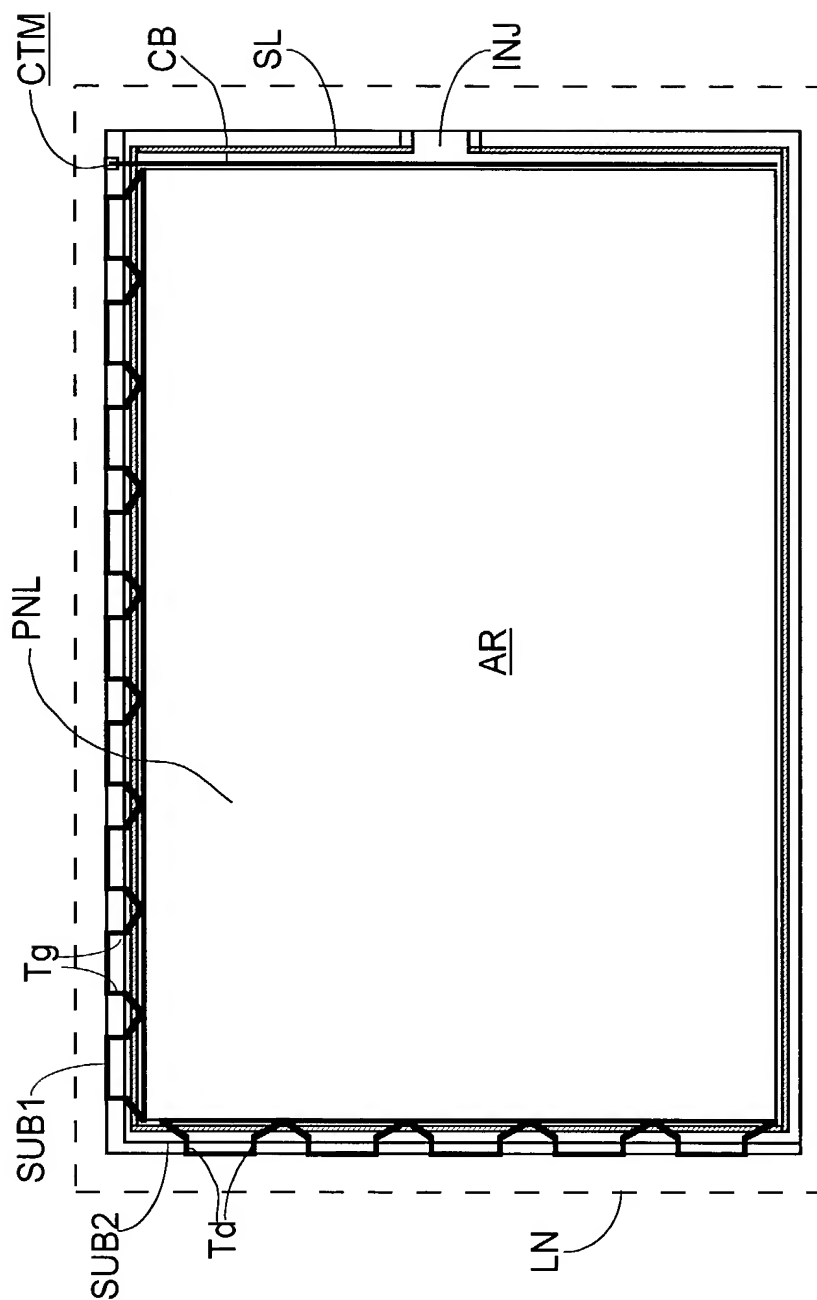


FIG. 6A

FIG. 6B

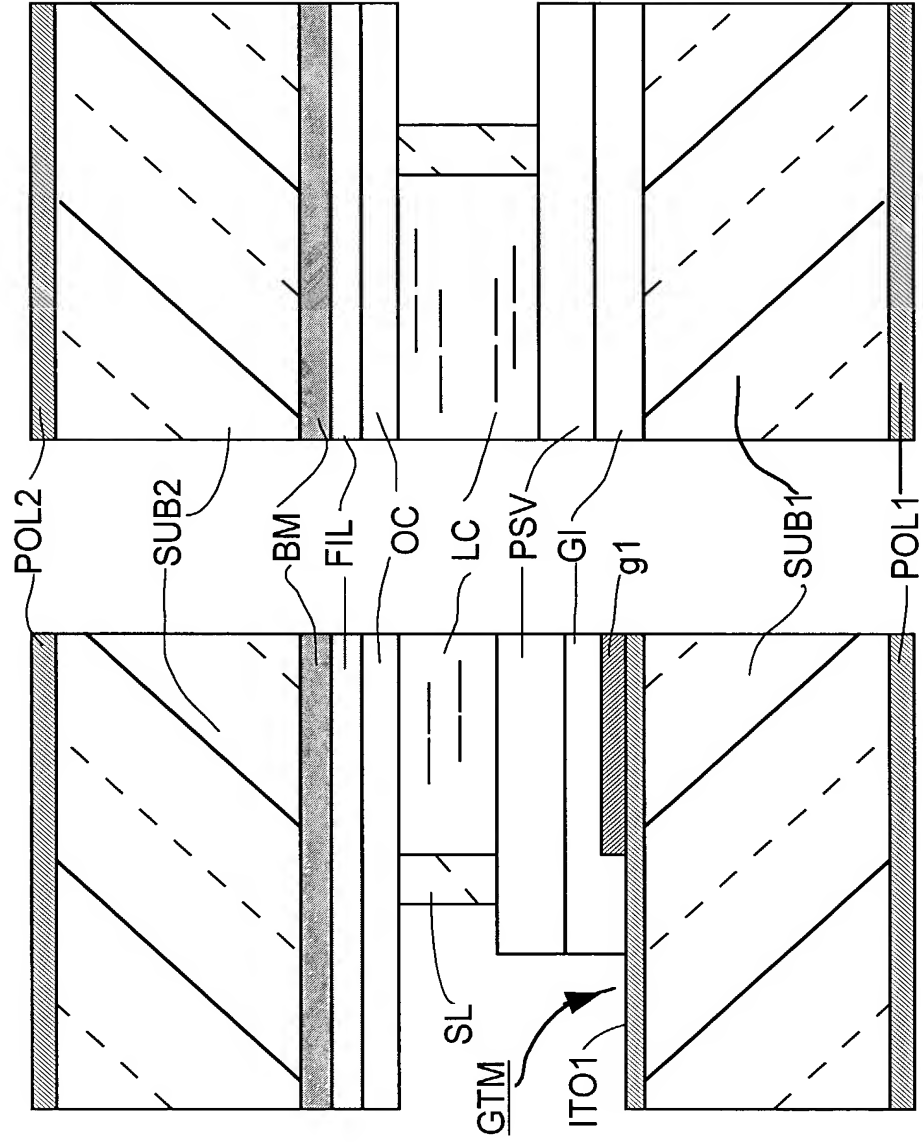


FIG. 7A

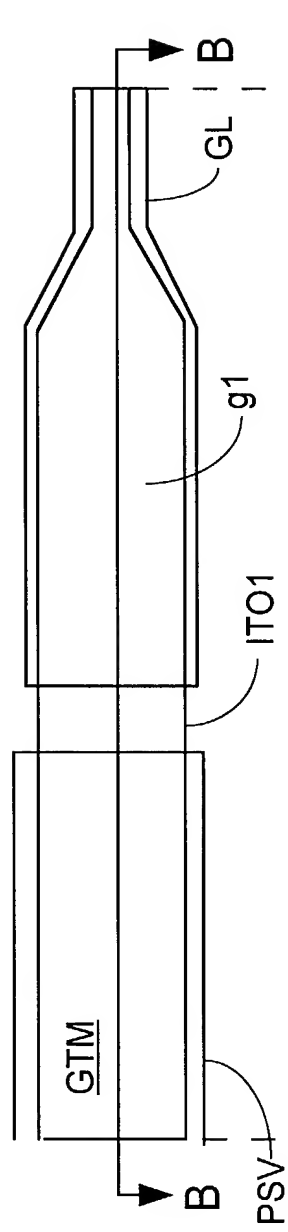


FIG. 7B

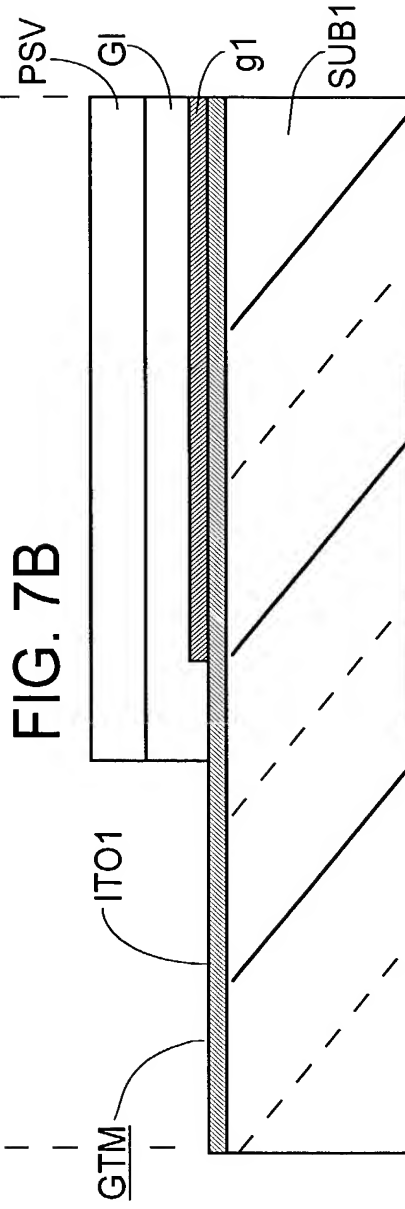


FIG. 8A

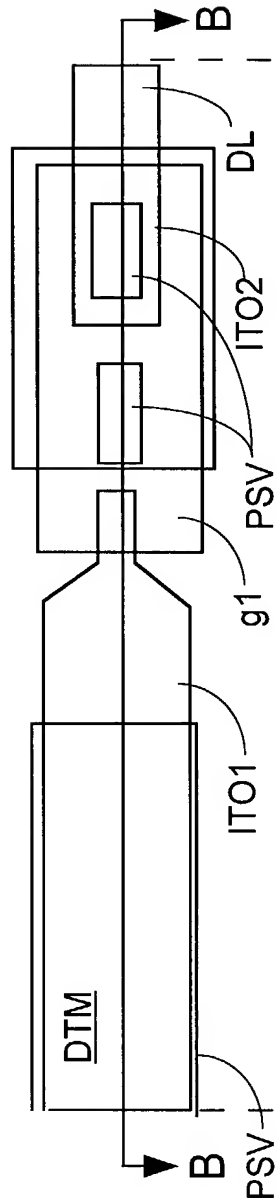


FIG. 8B

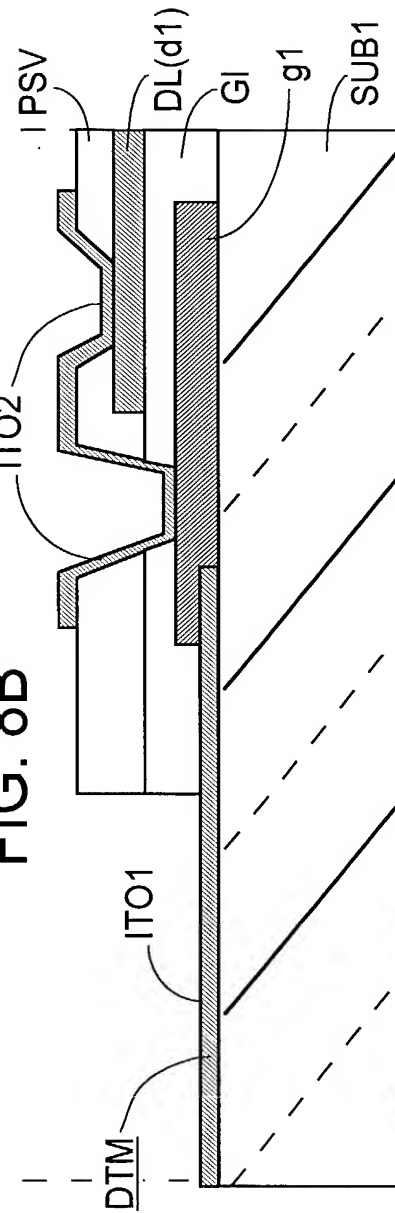


FIG. 9A

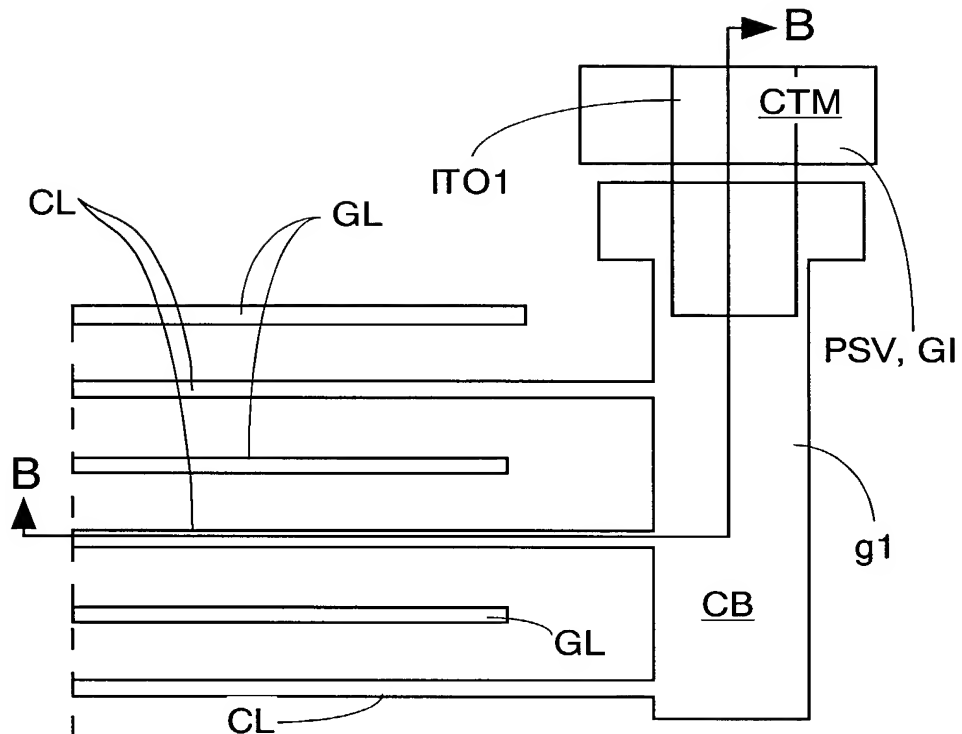


FIG. 9B

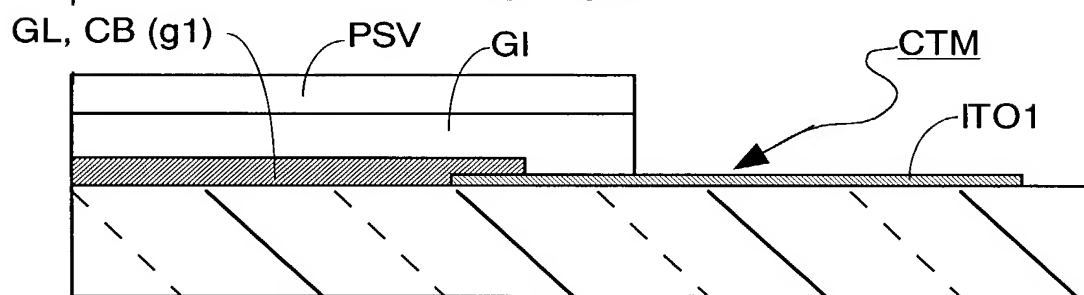


FIG. 10

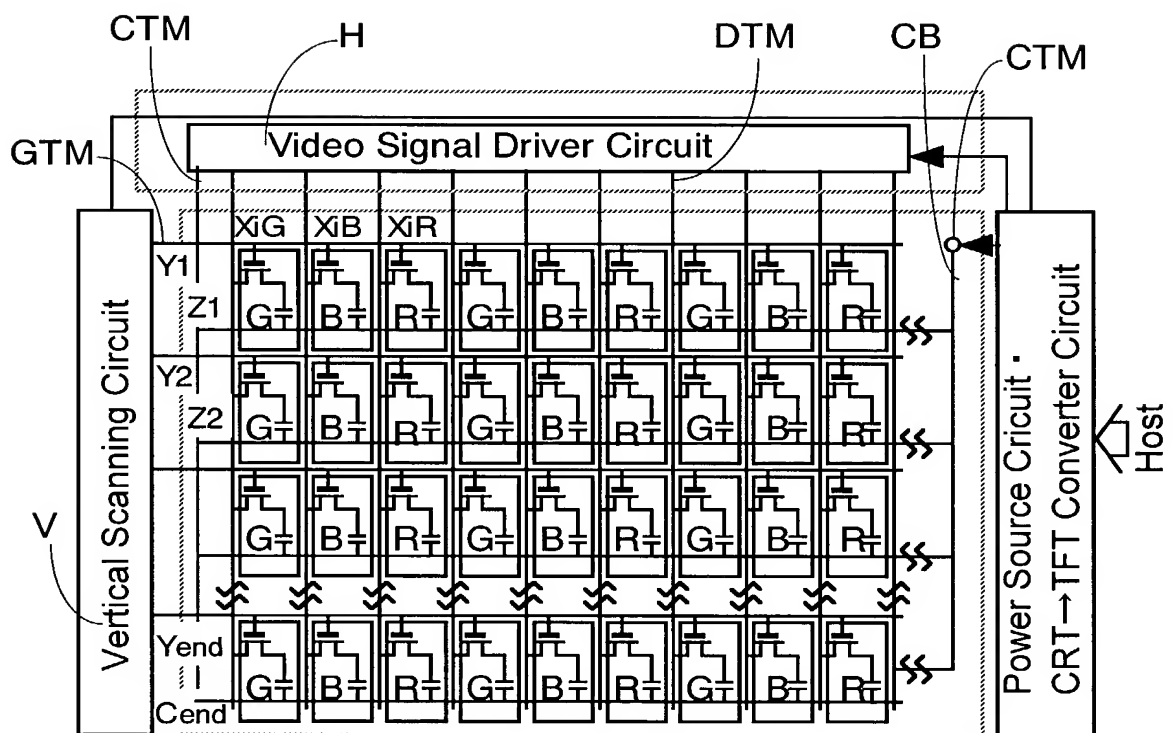


FIG. 11

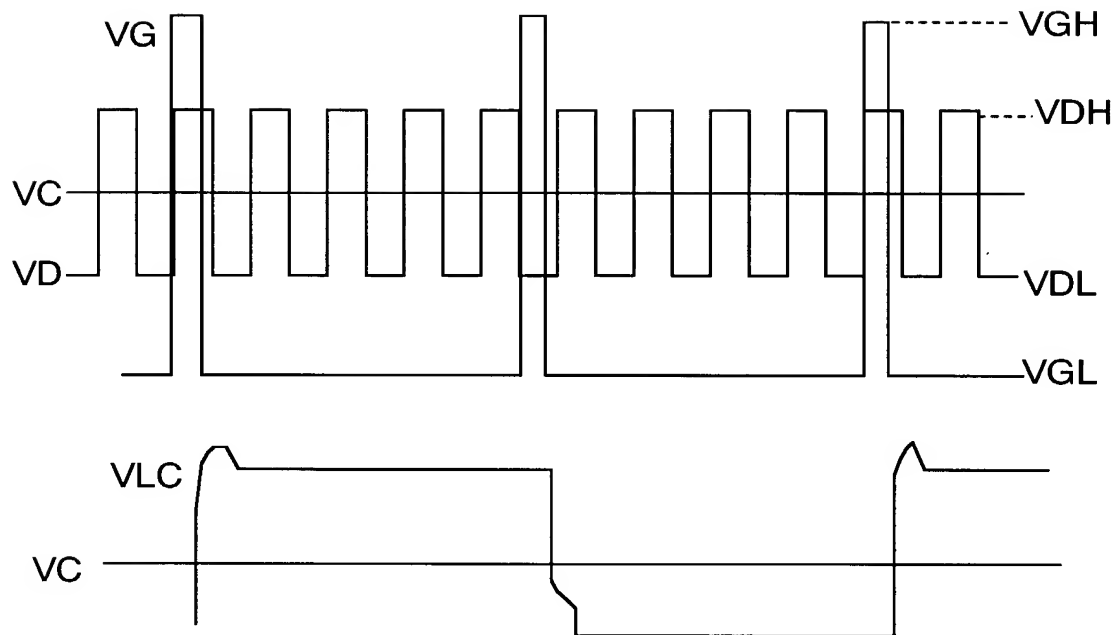


FIG. 12

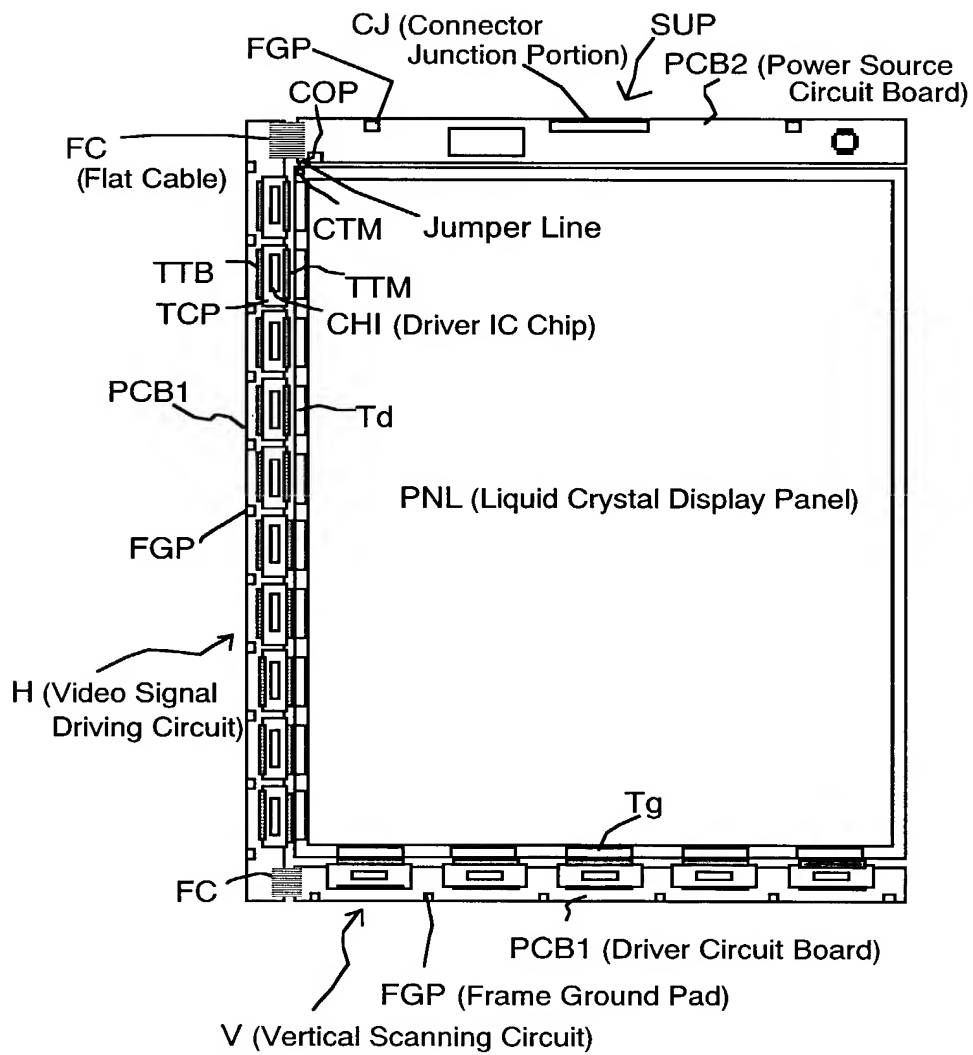


FIG. 13

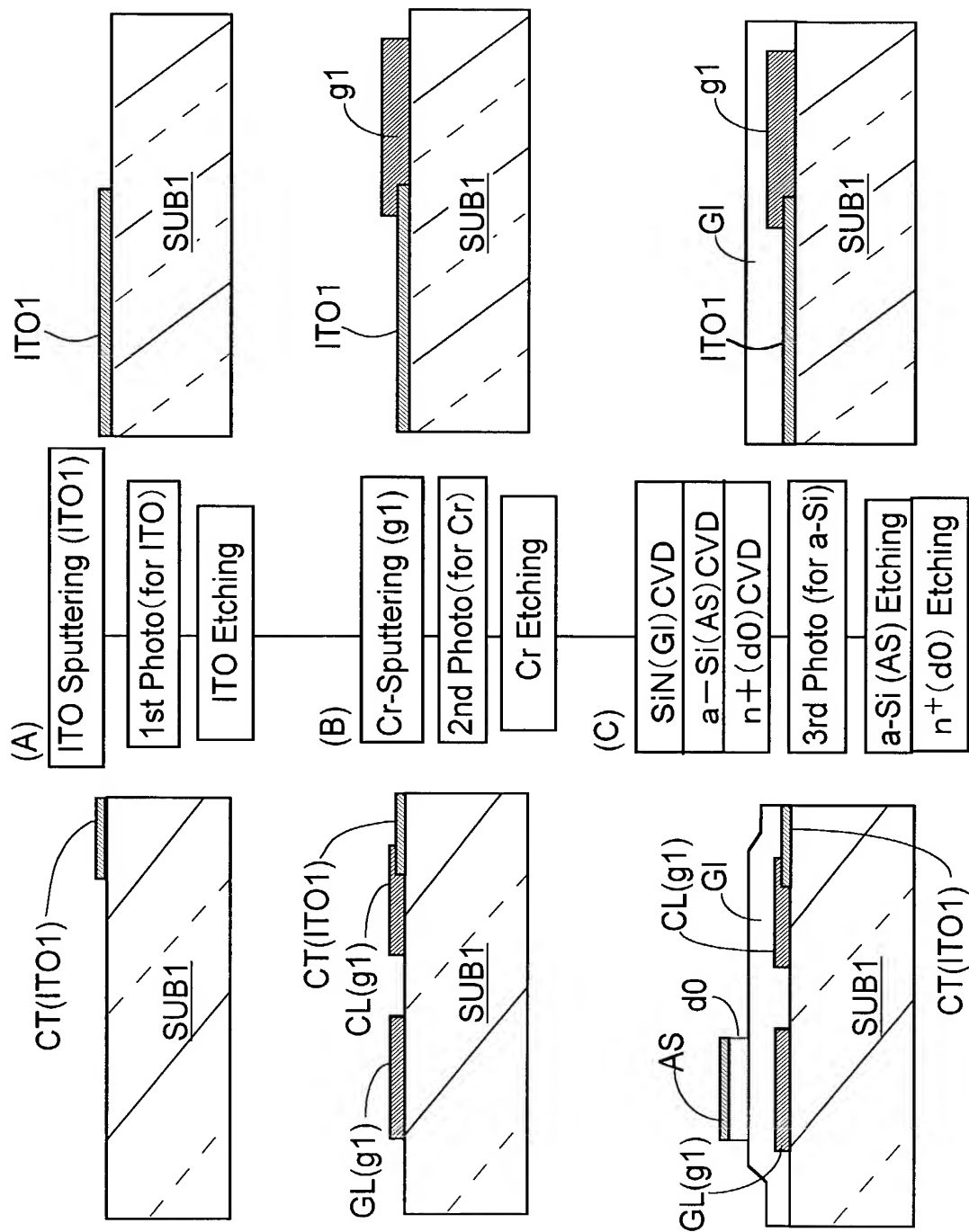


FIG. 14

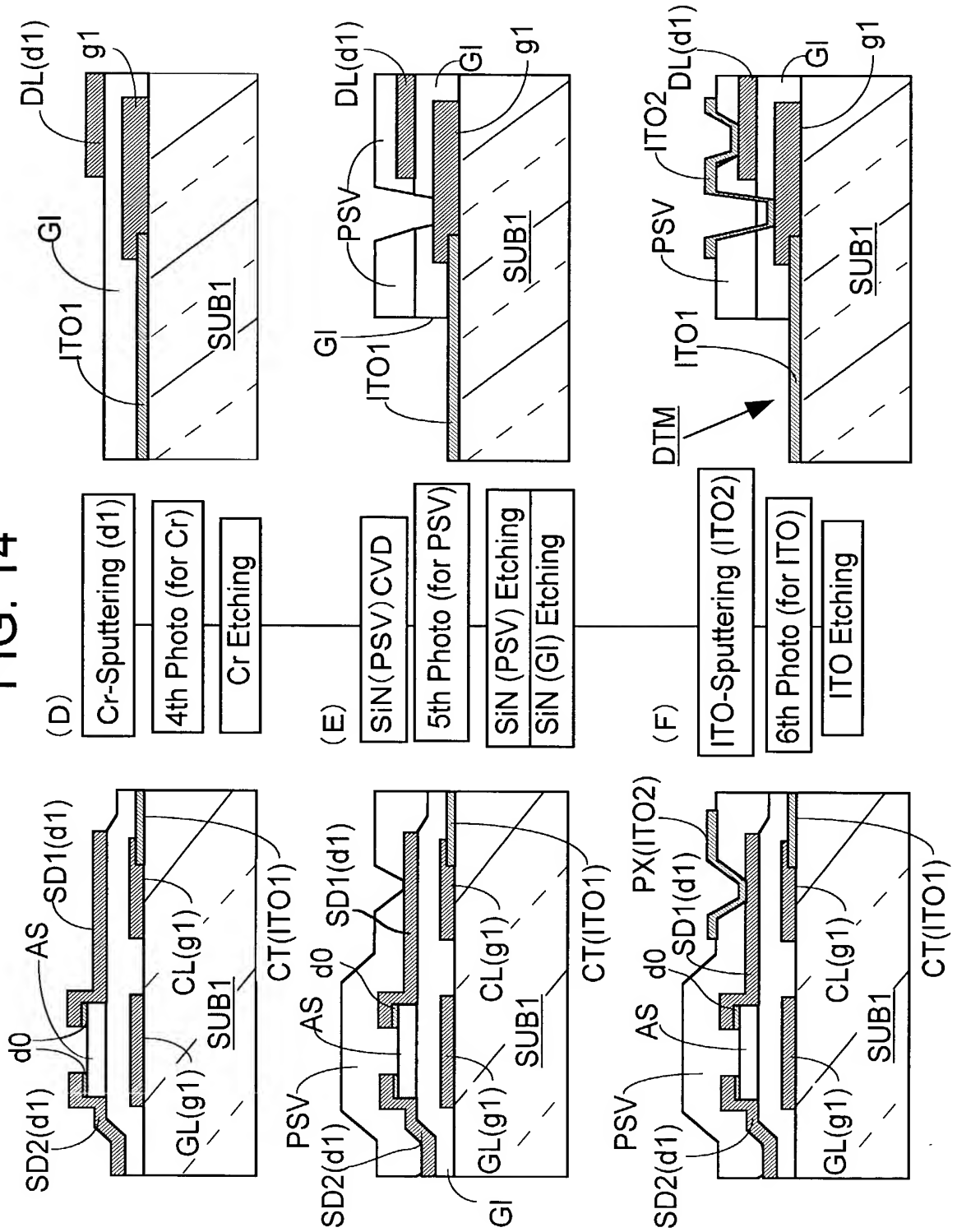


FIG. 15

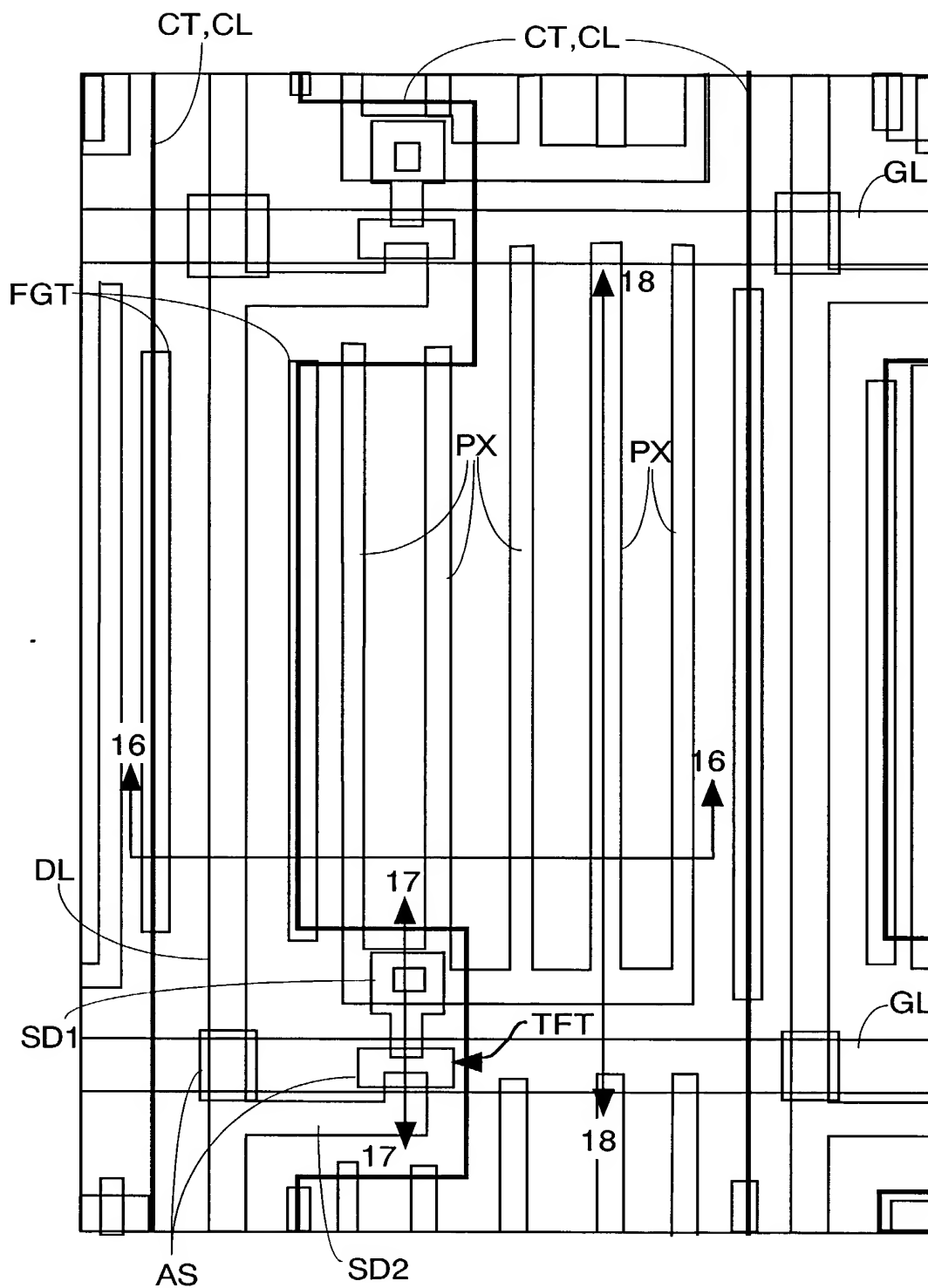


FIG. 16

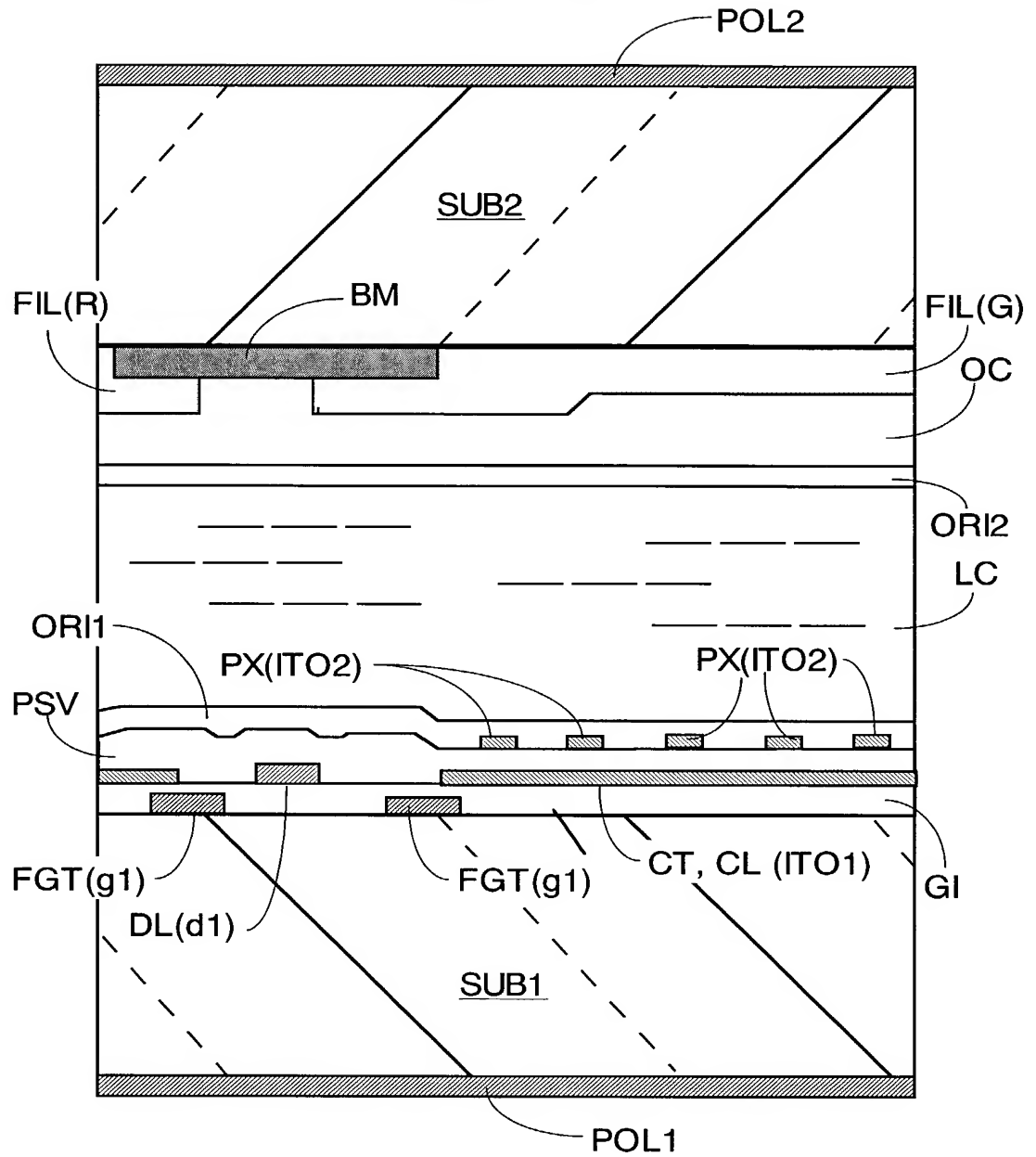


FIG. 17

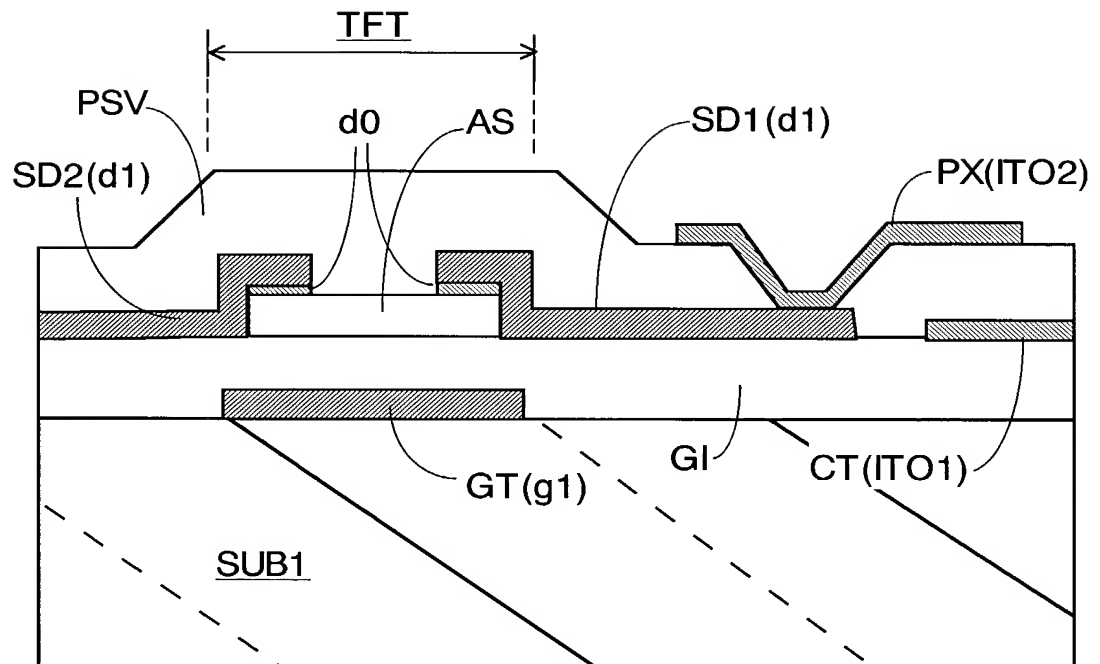


FIG. 18

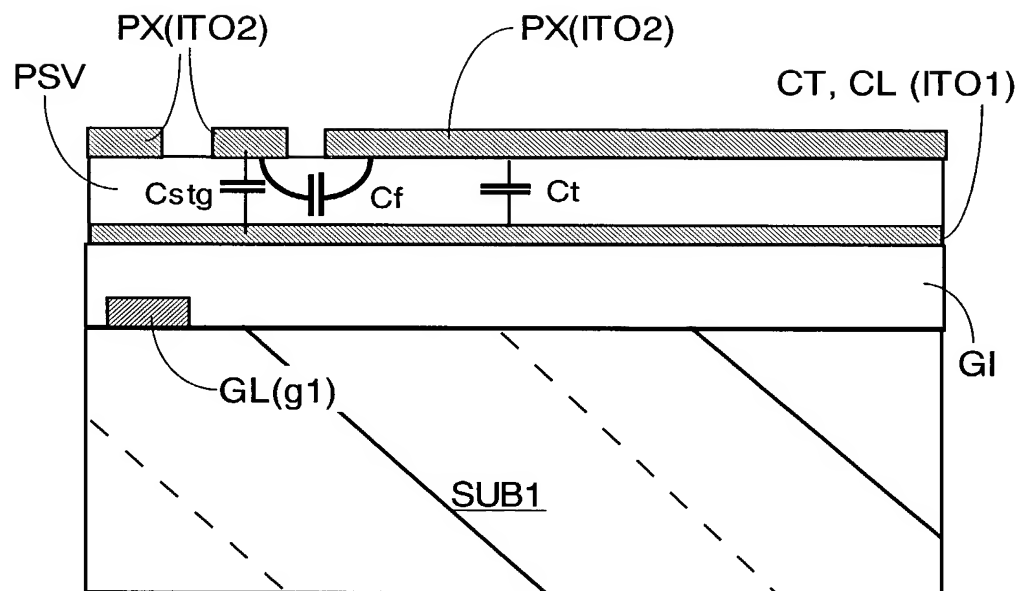


FIG. 19

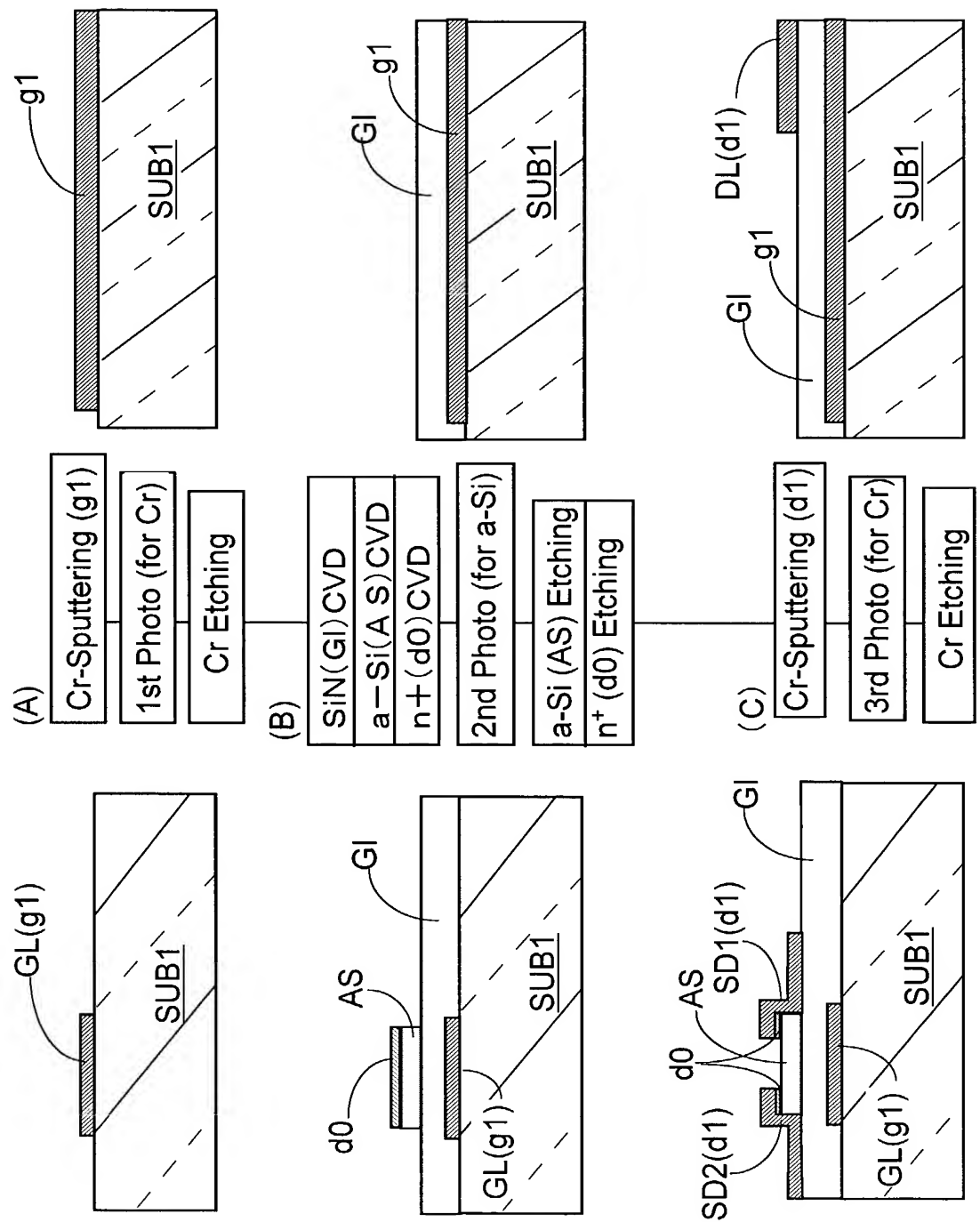


FIG. 20

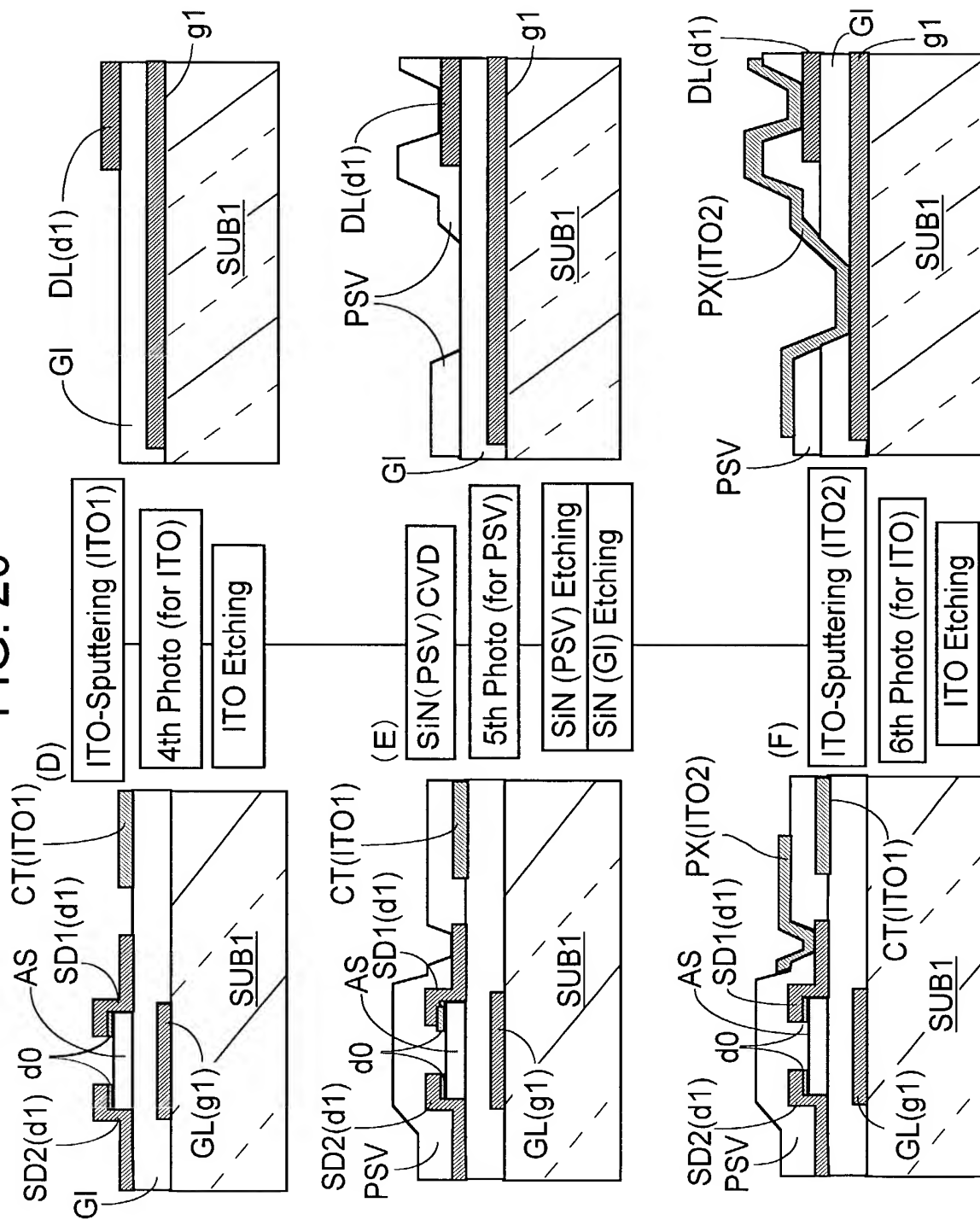


FIG. 21

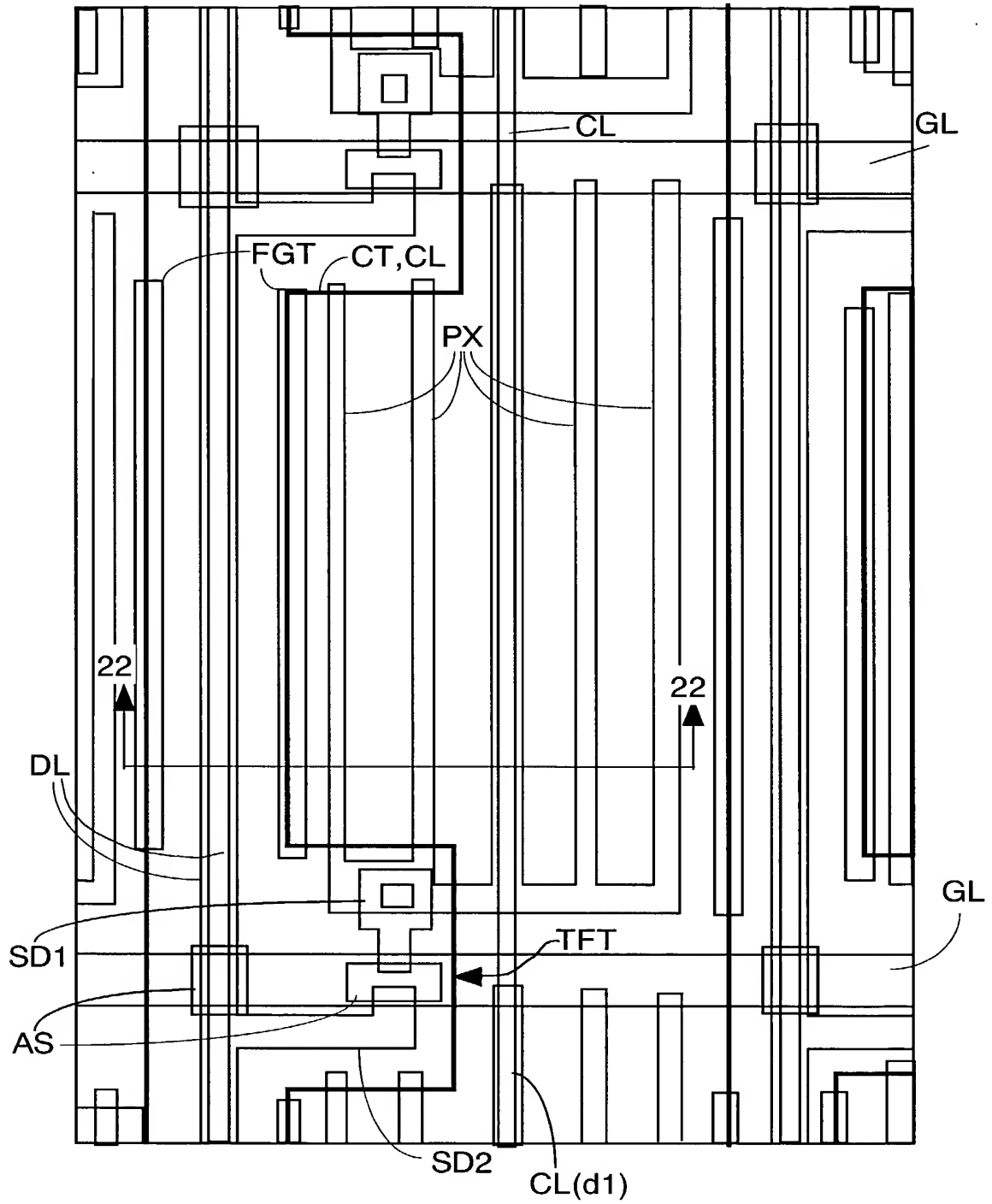


FIG. 22

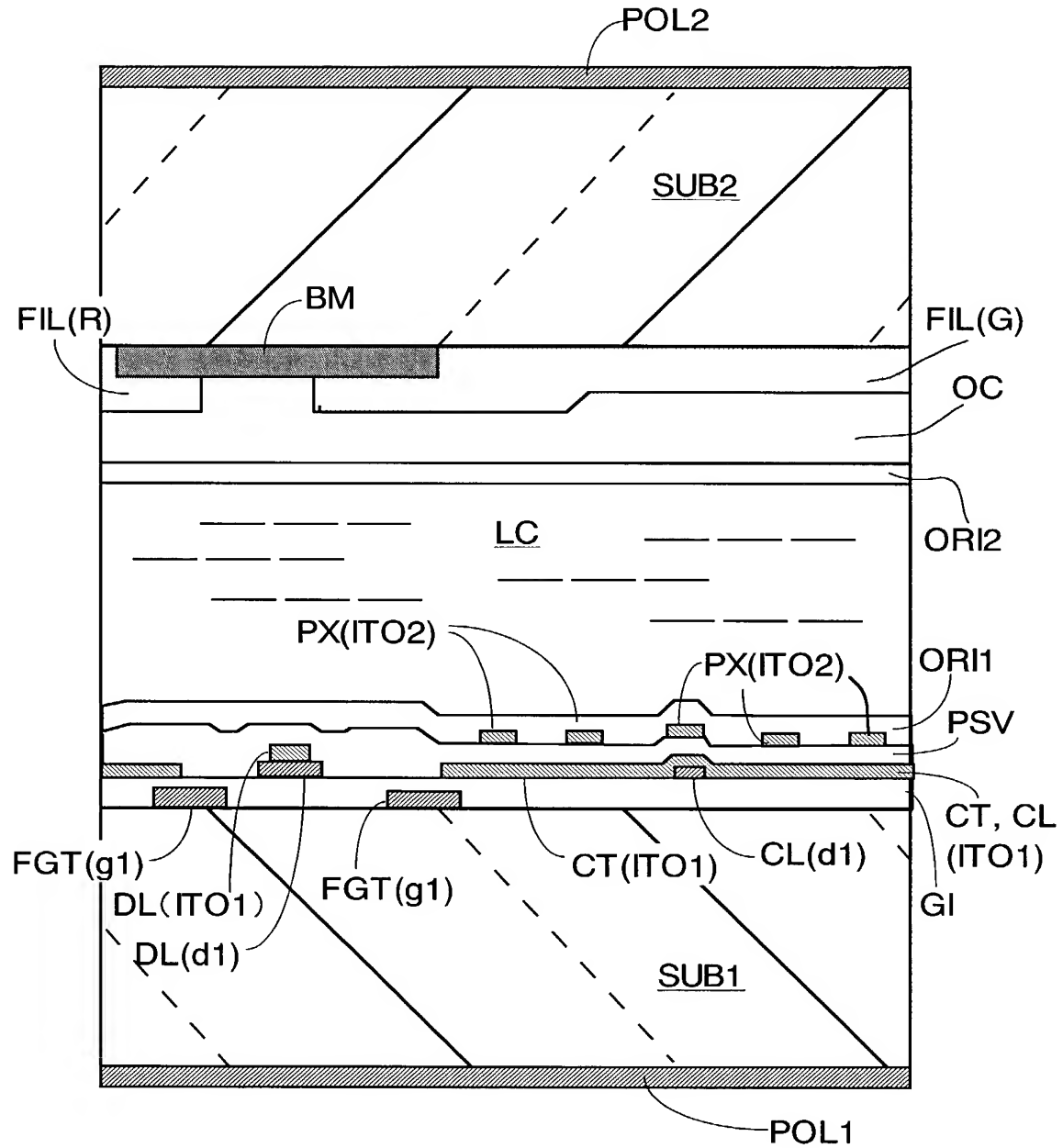


FIG. 23

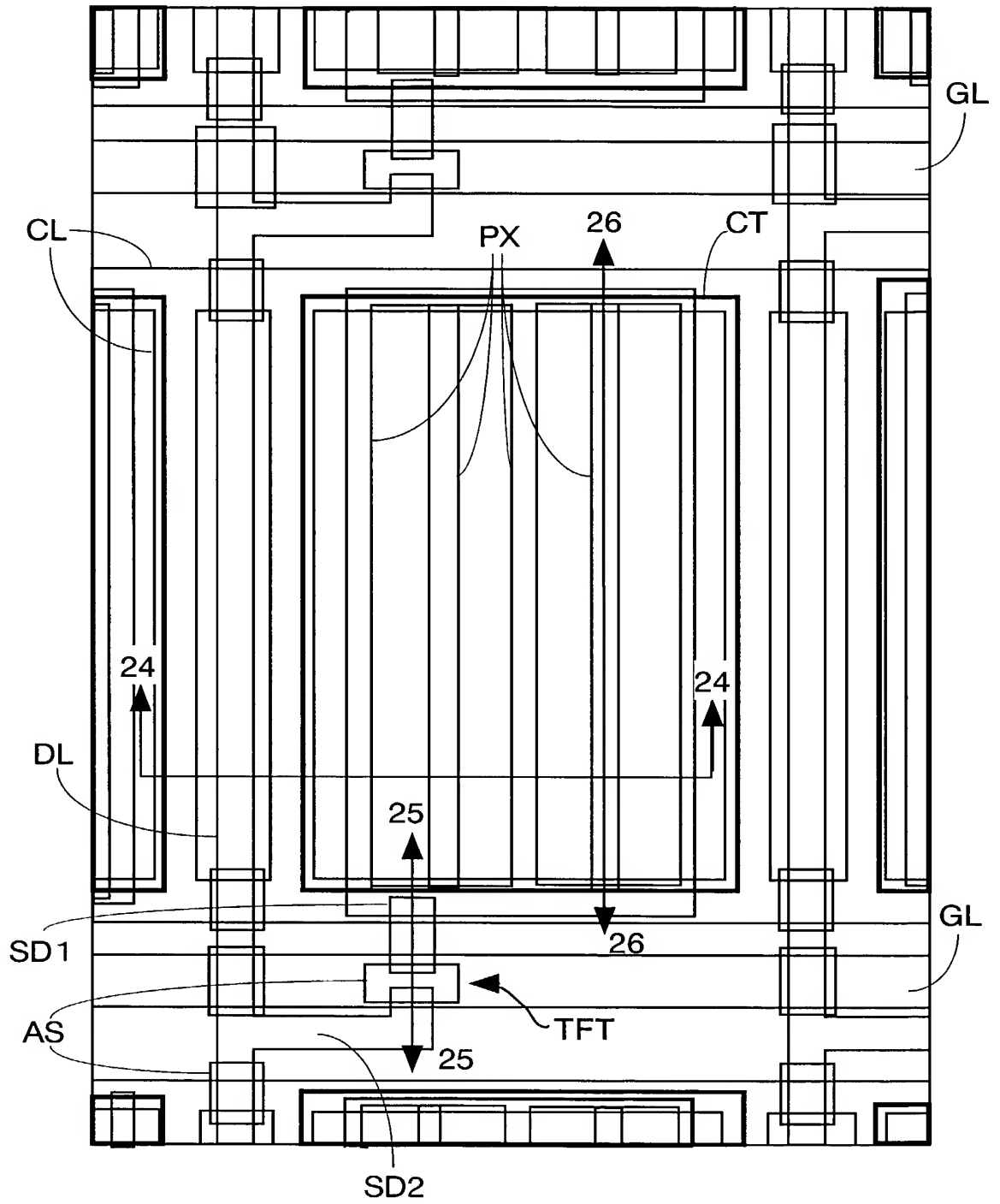


FIG. 24

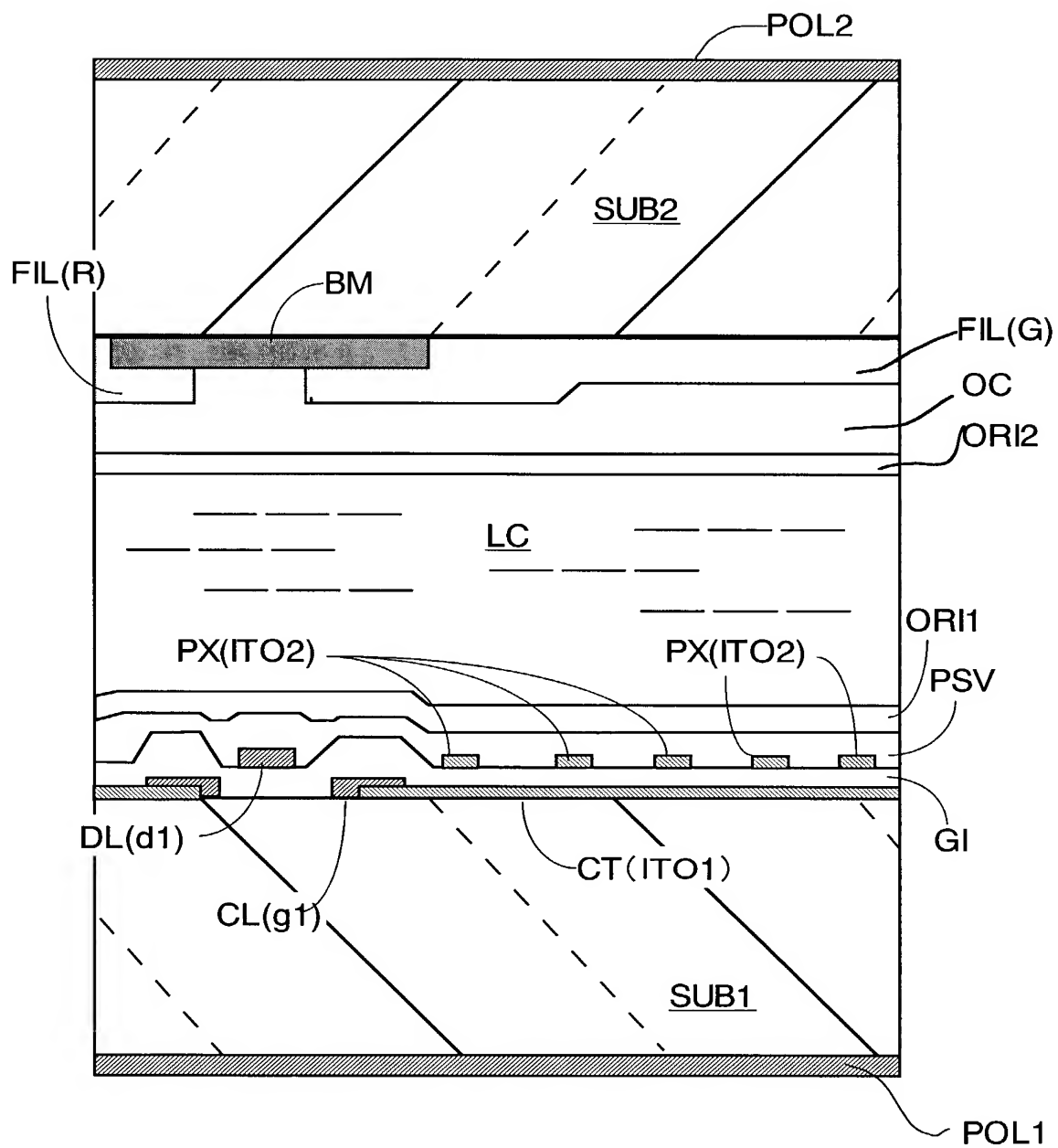


FIG. 25

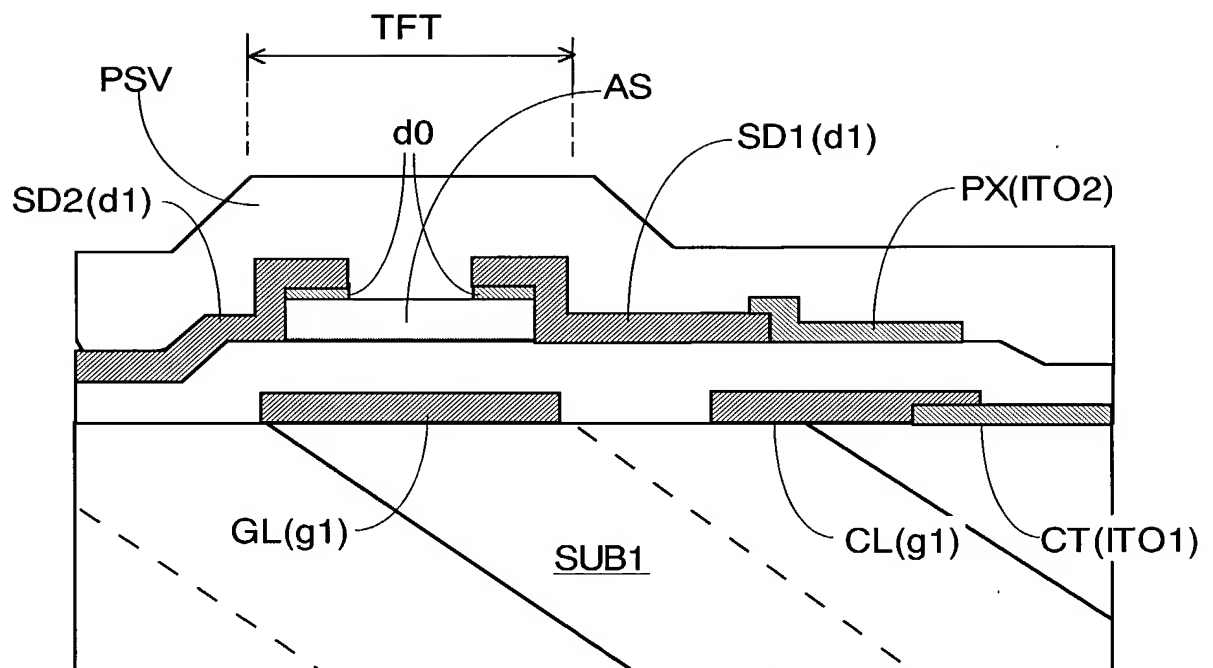


FIG. 26

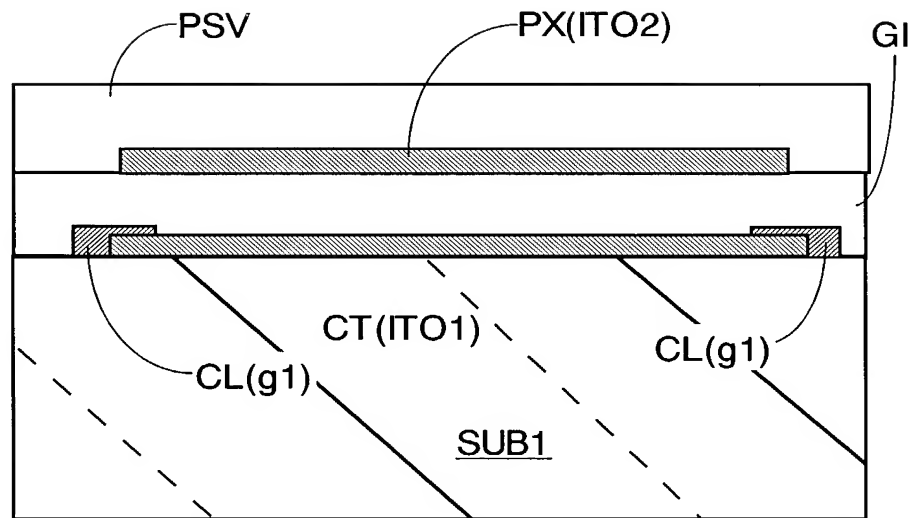


FIG. 27

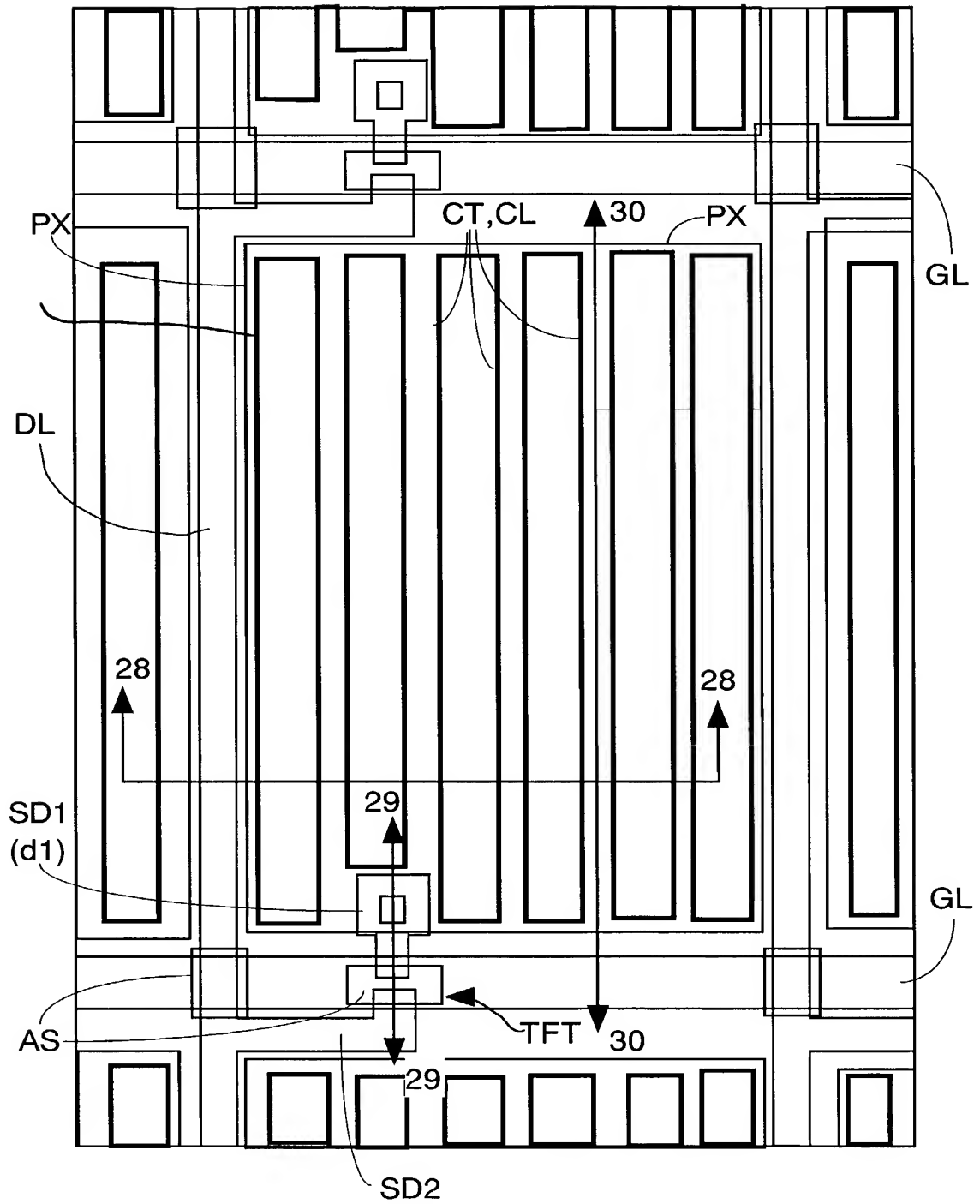


FIG. 28

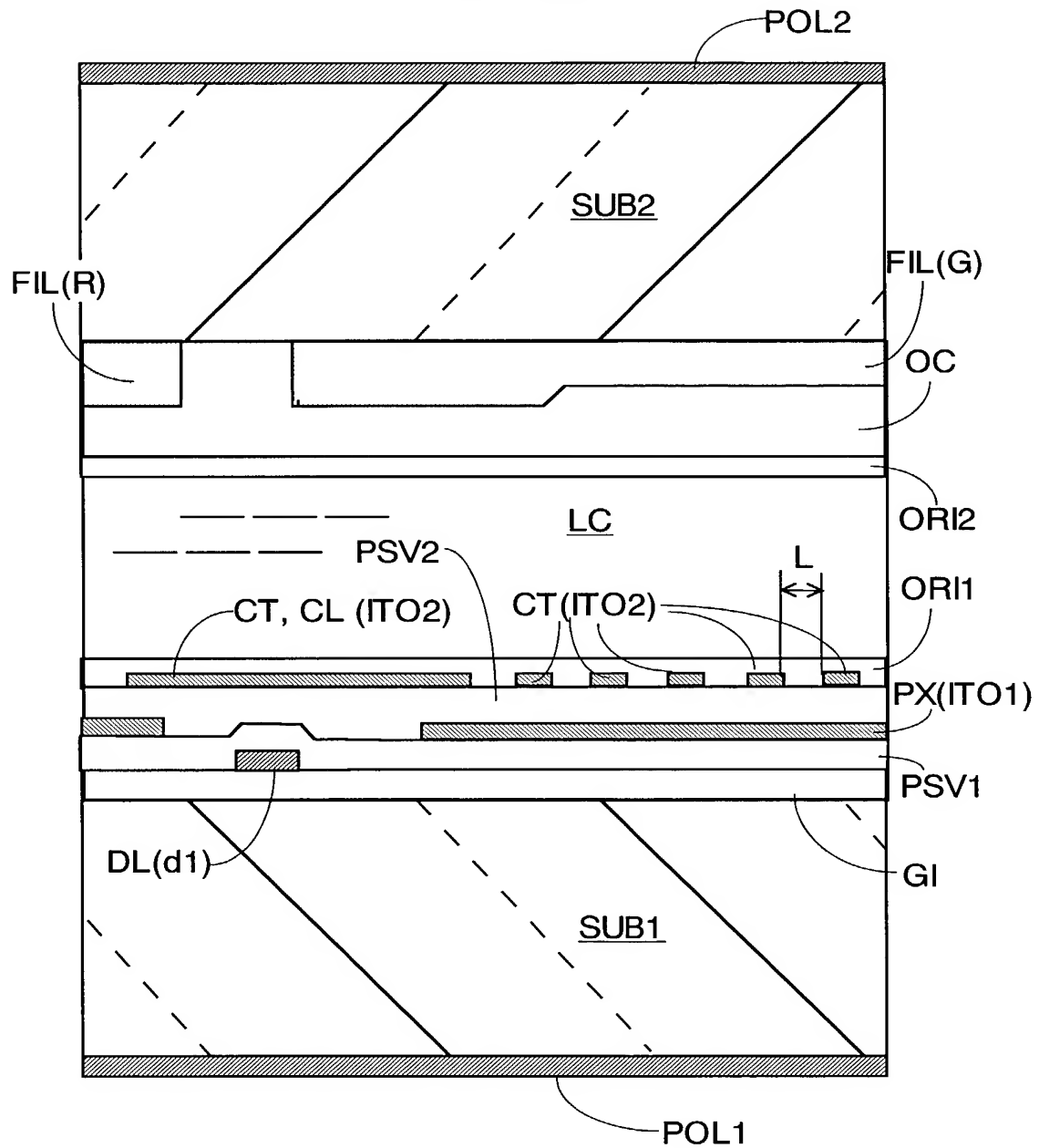


FIG. 29

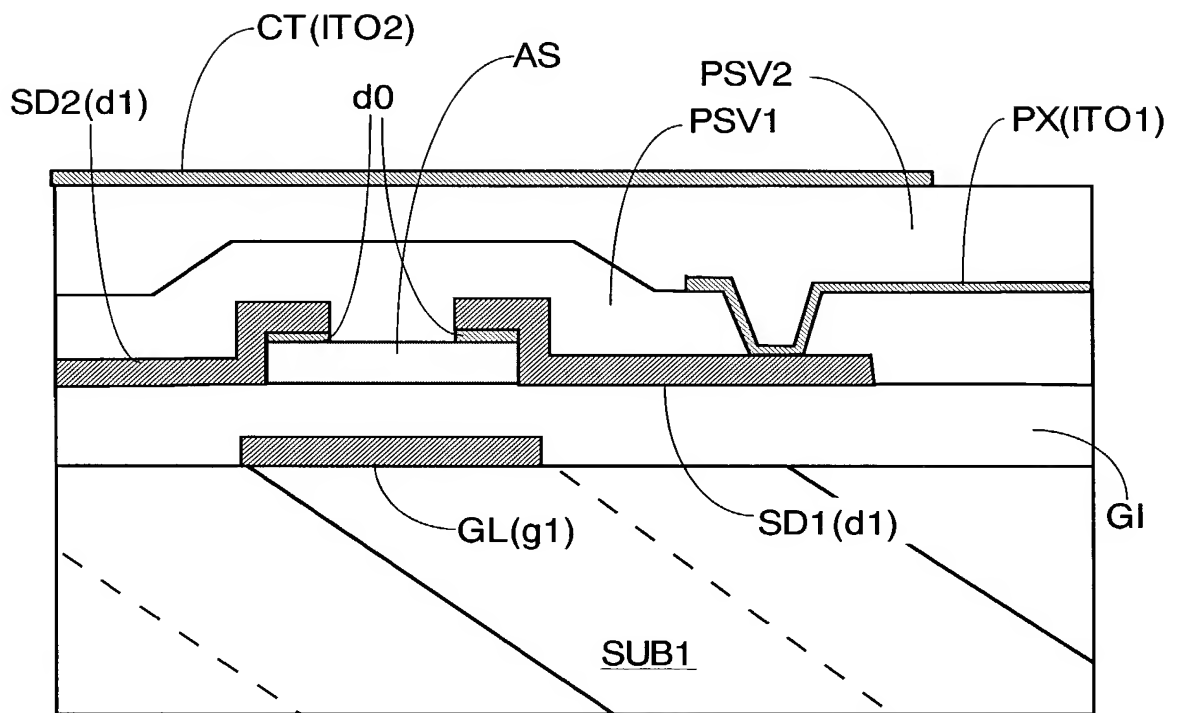


FIG. 30

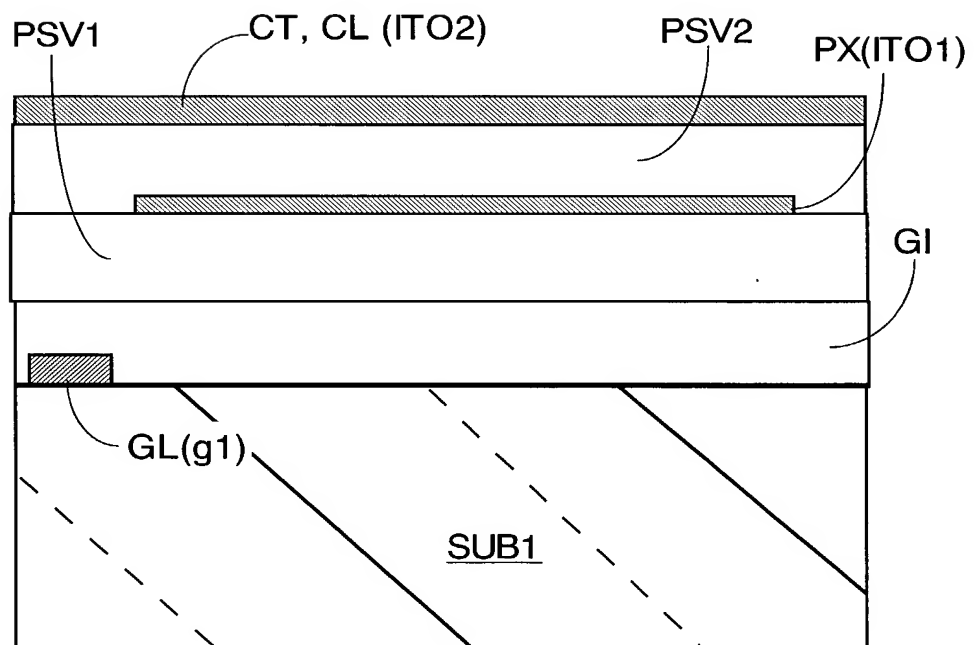


FIG. 31

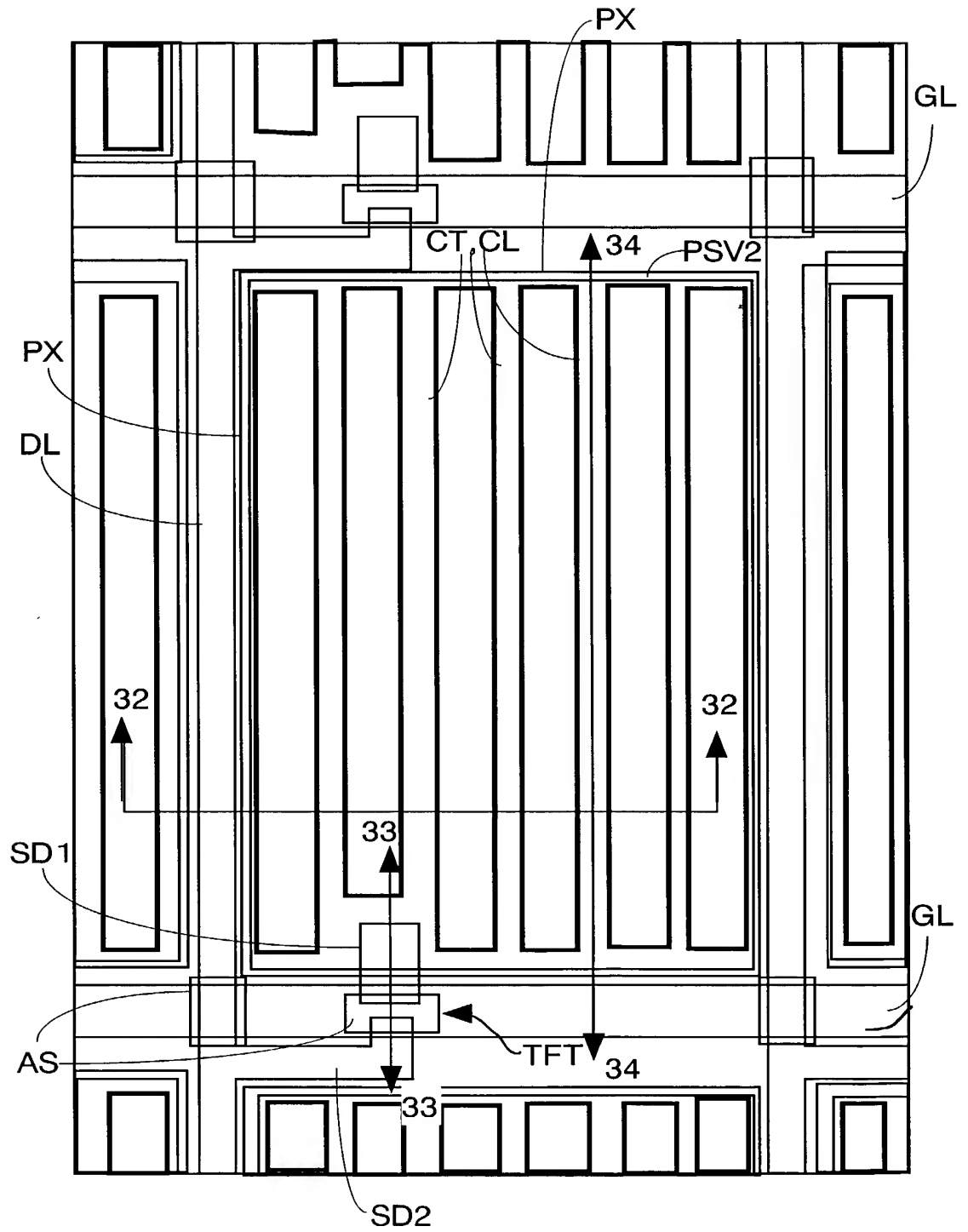


FIG. 32

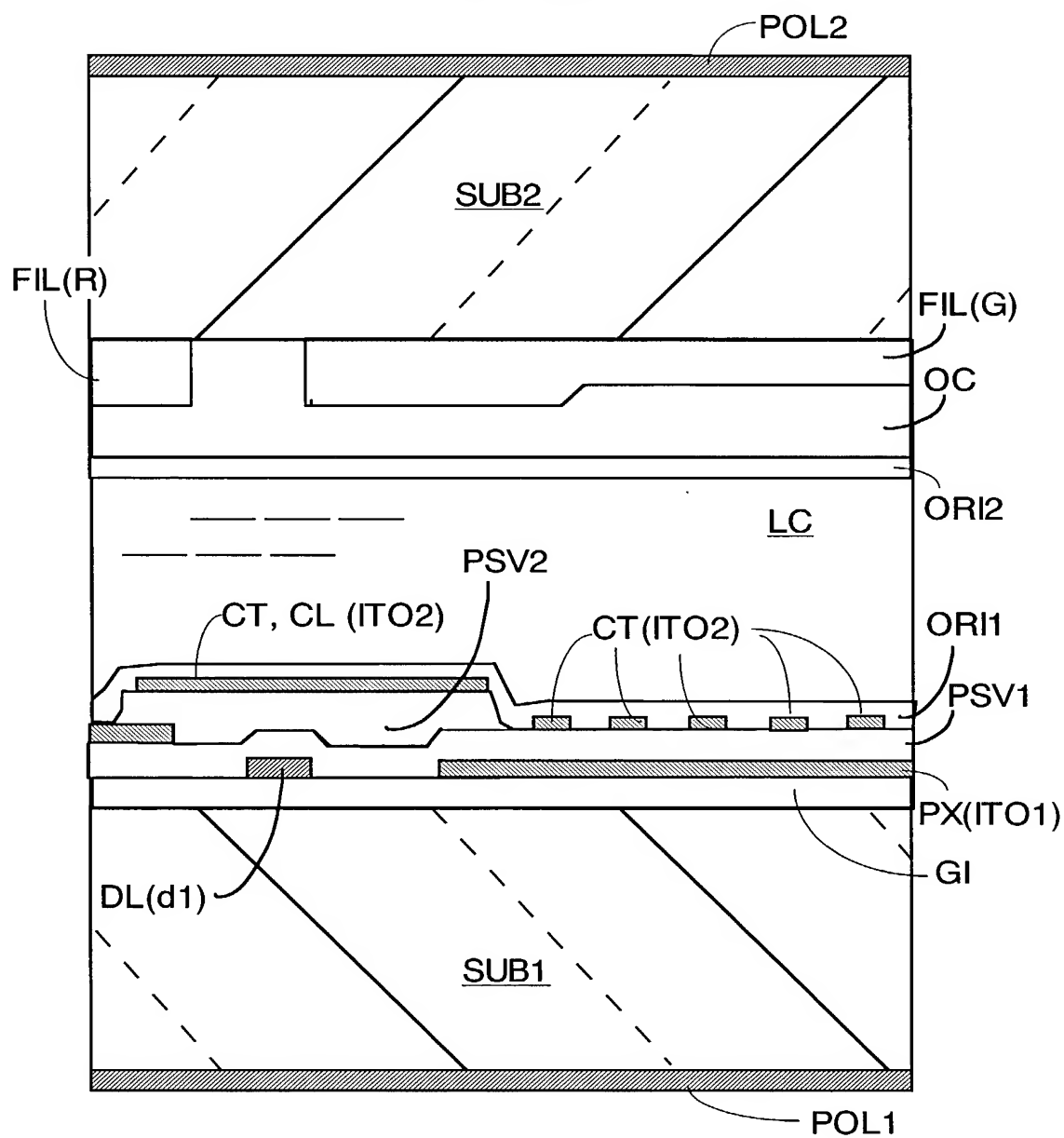
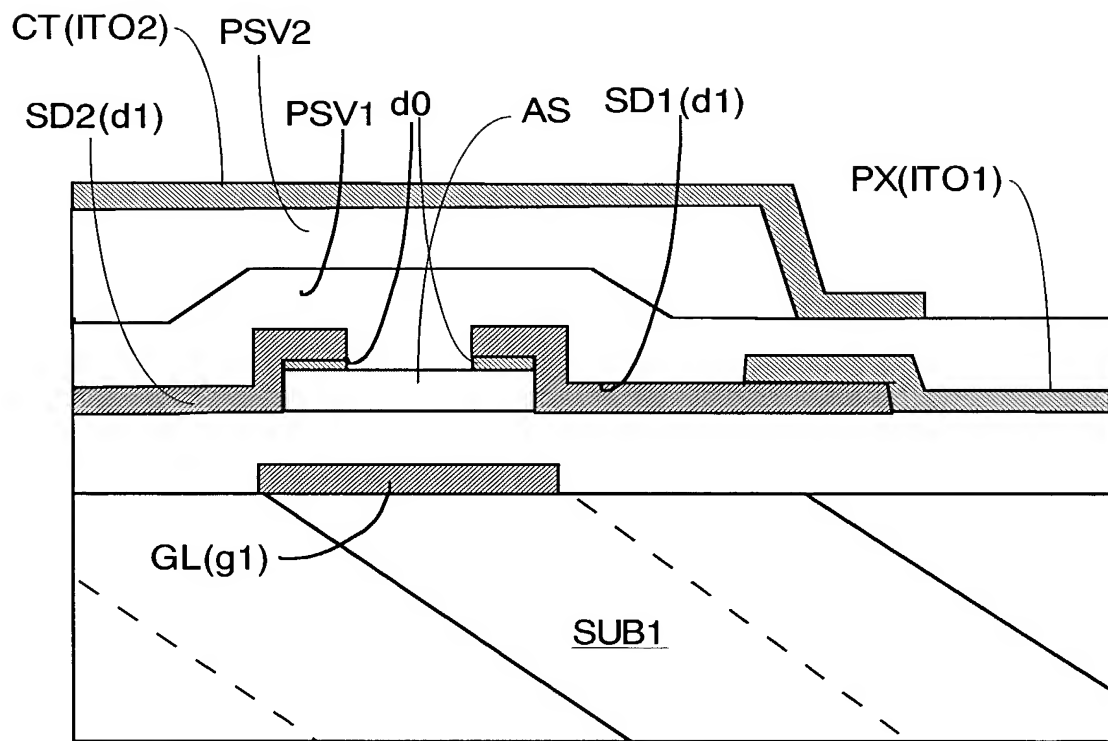


FIG. 33



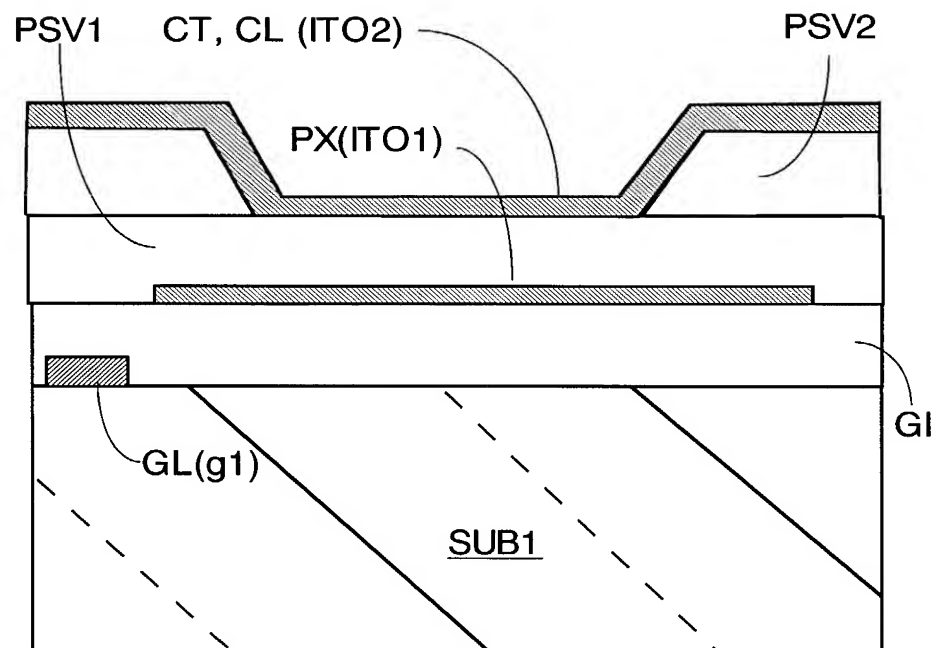


FIG. 35

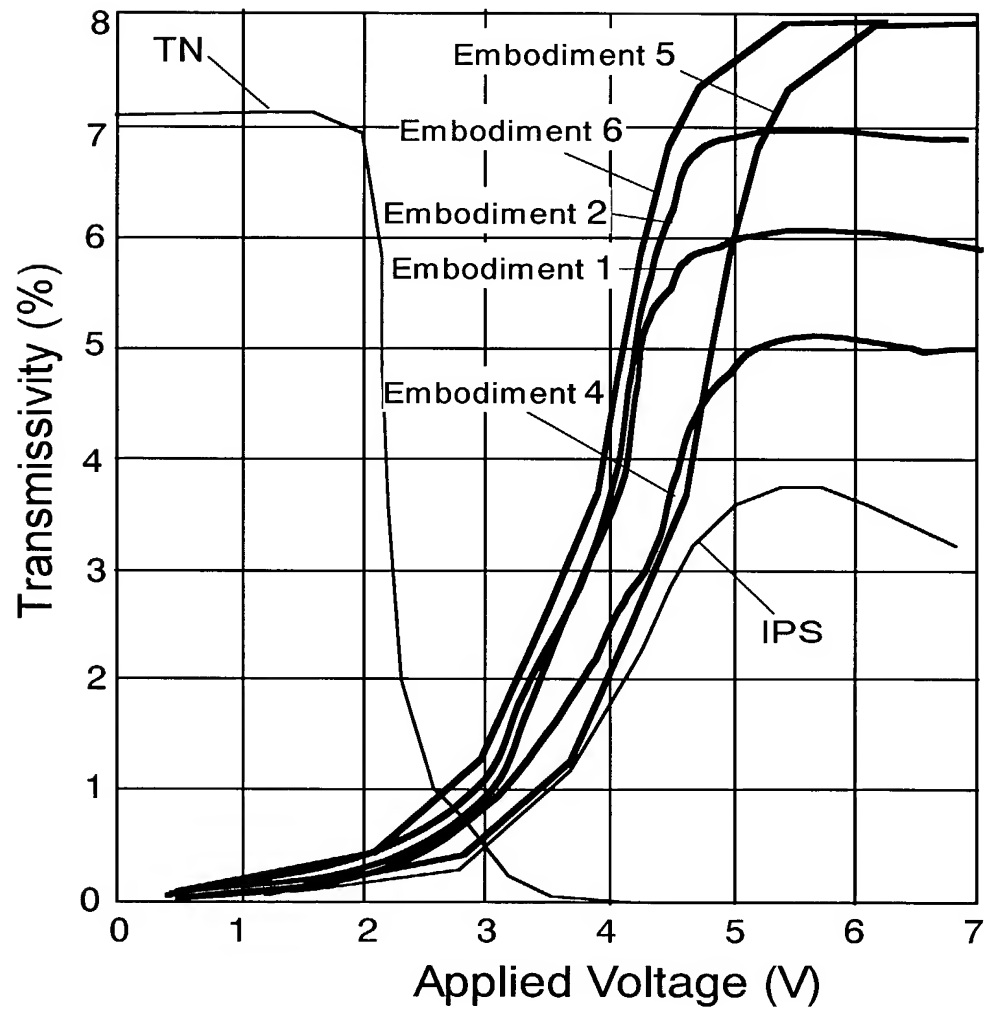


FIG. 36

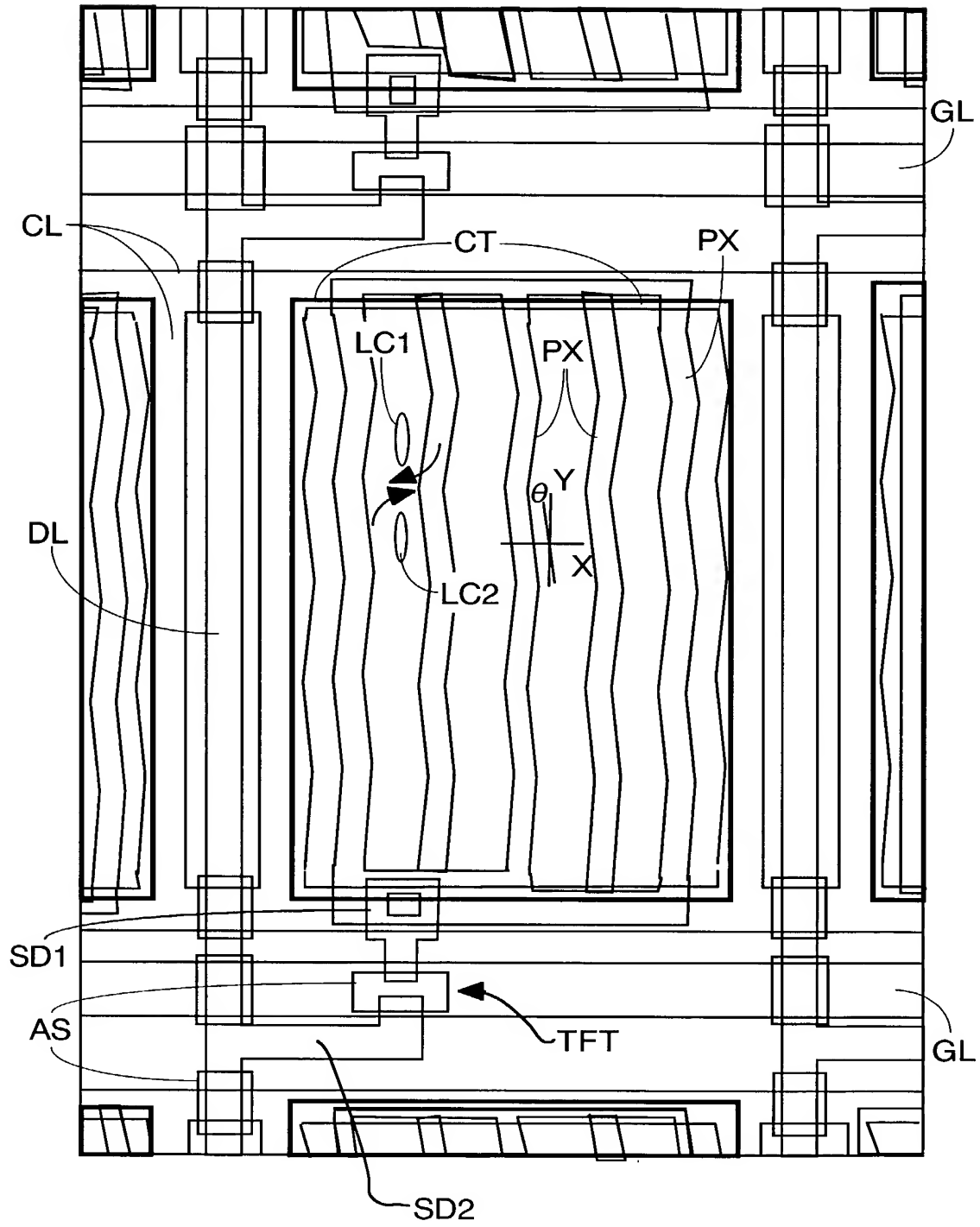


FIG. 37

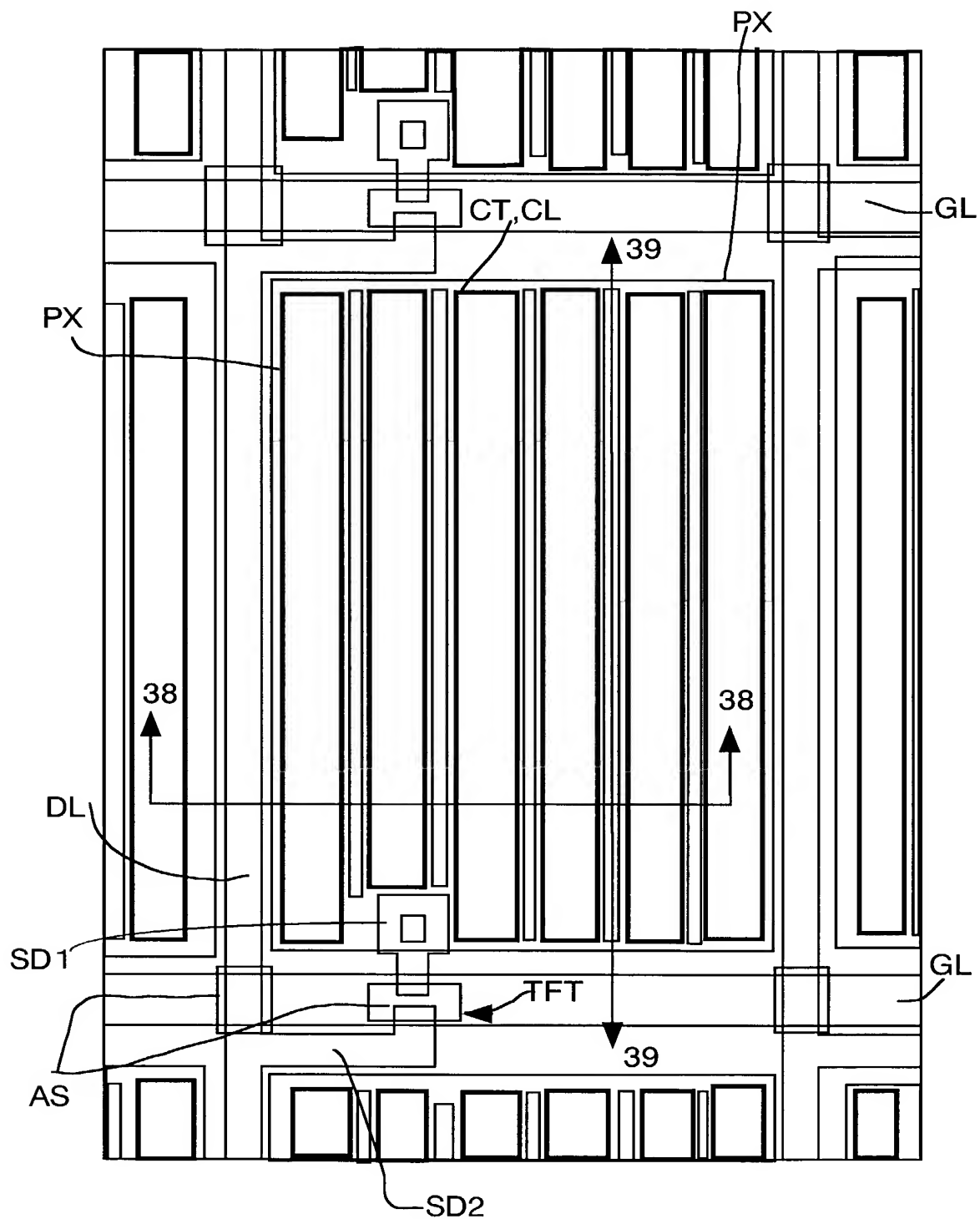


FIG. 38

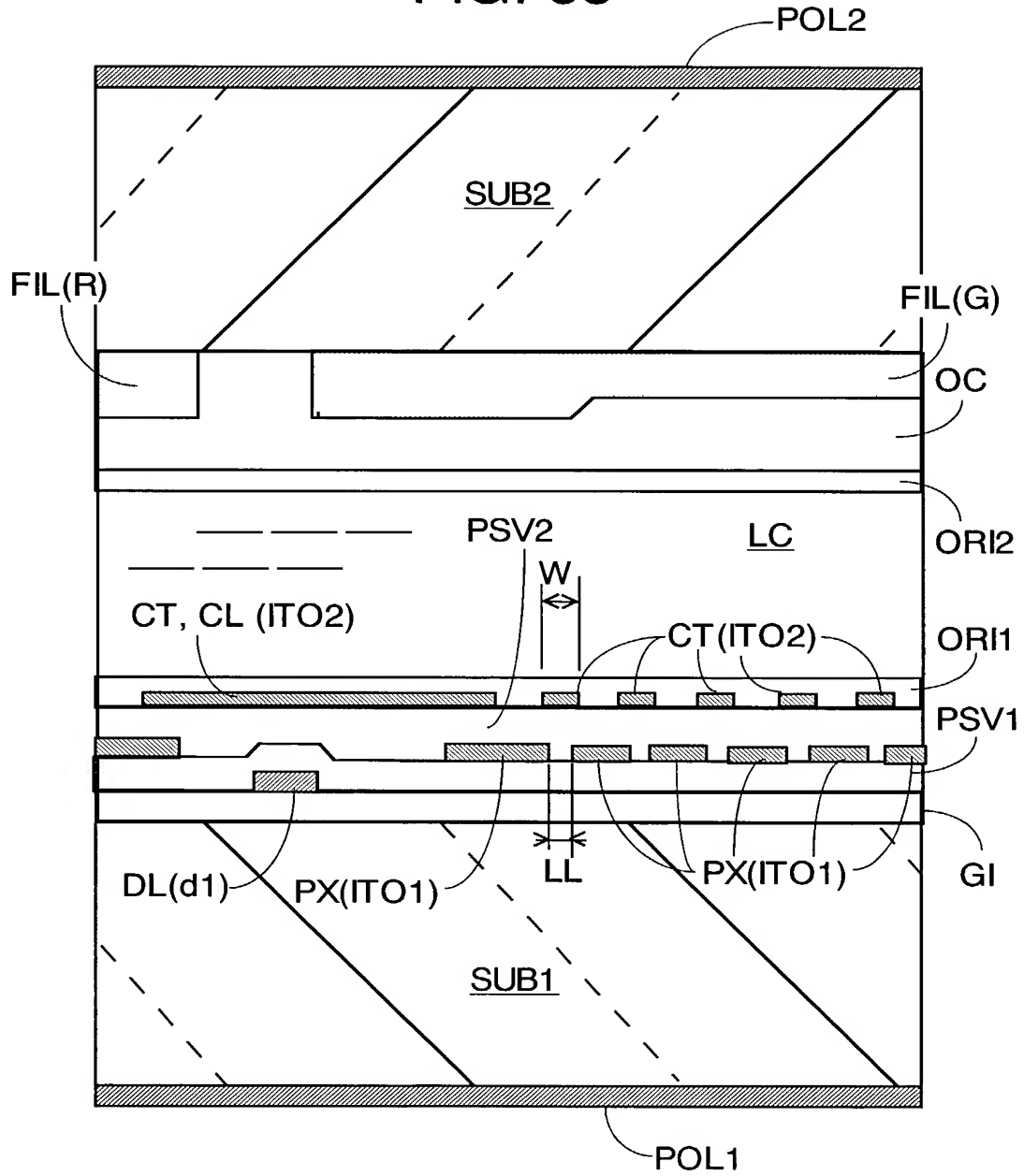


FIG. 39

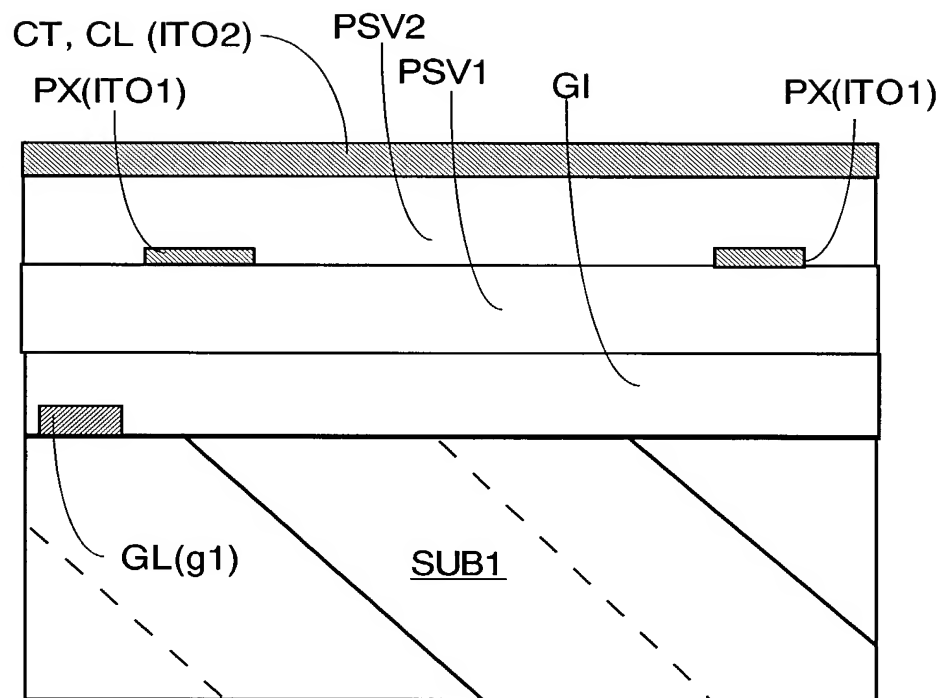


FIG. 40

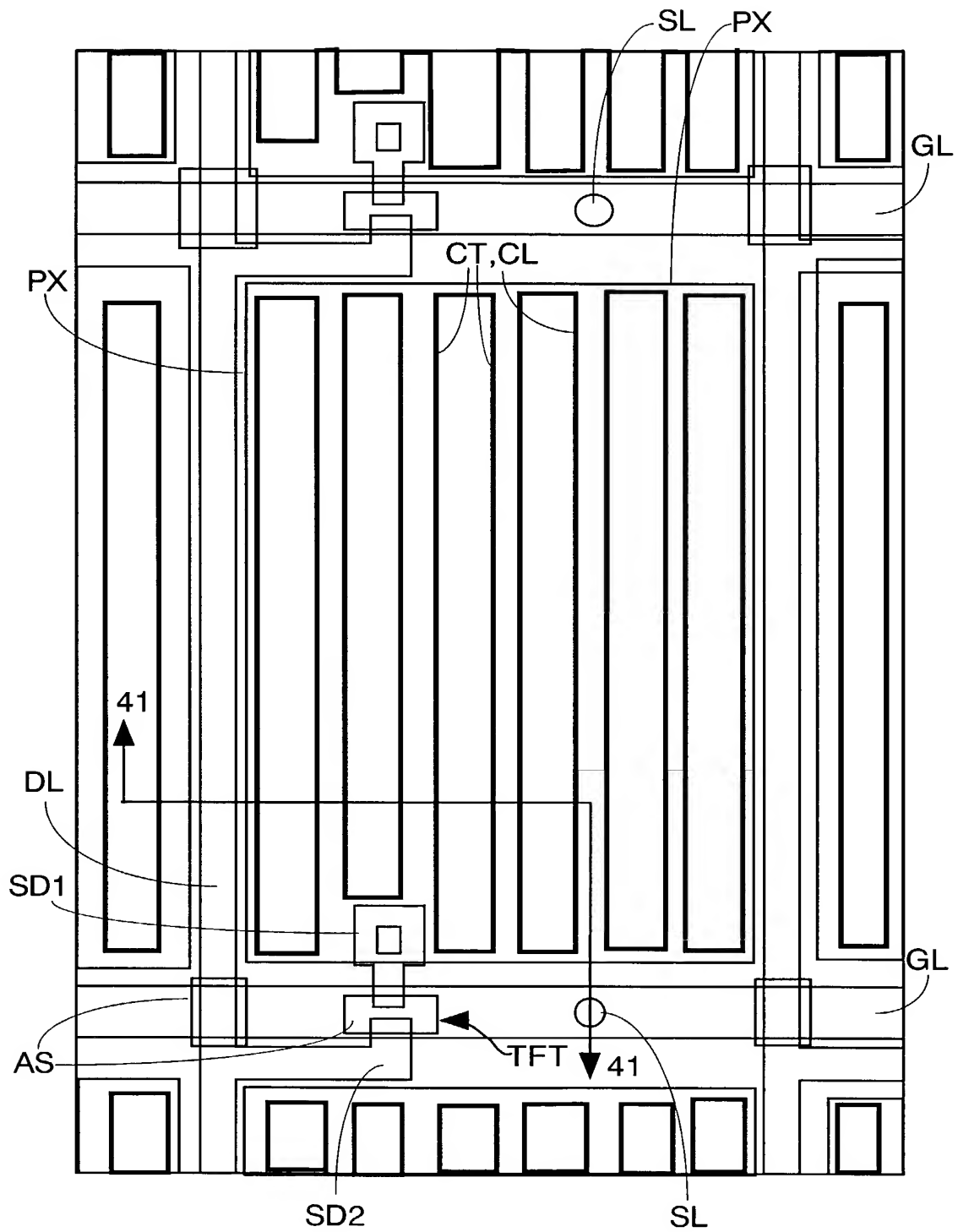


FIG. 41

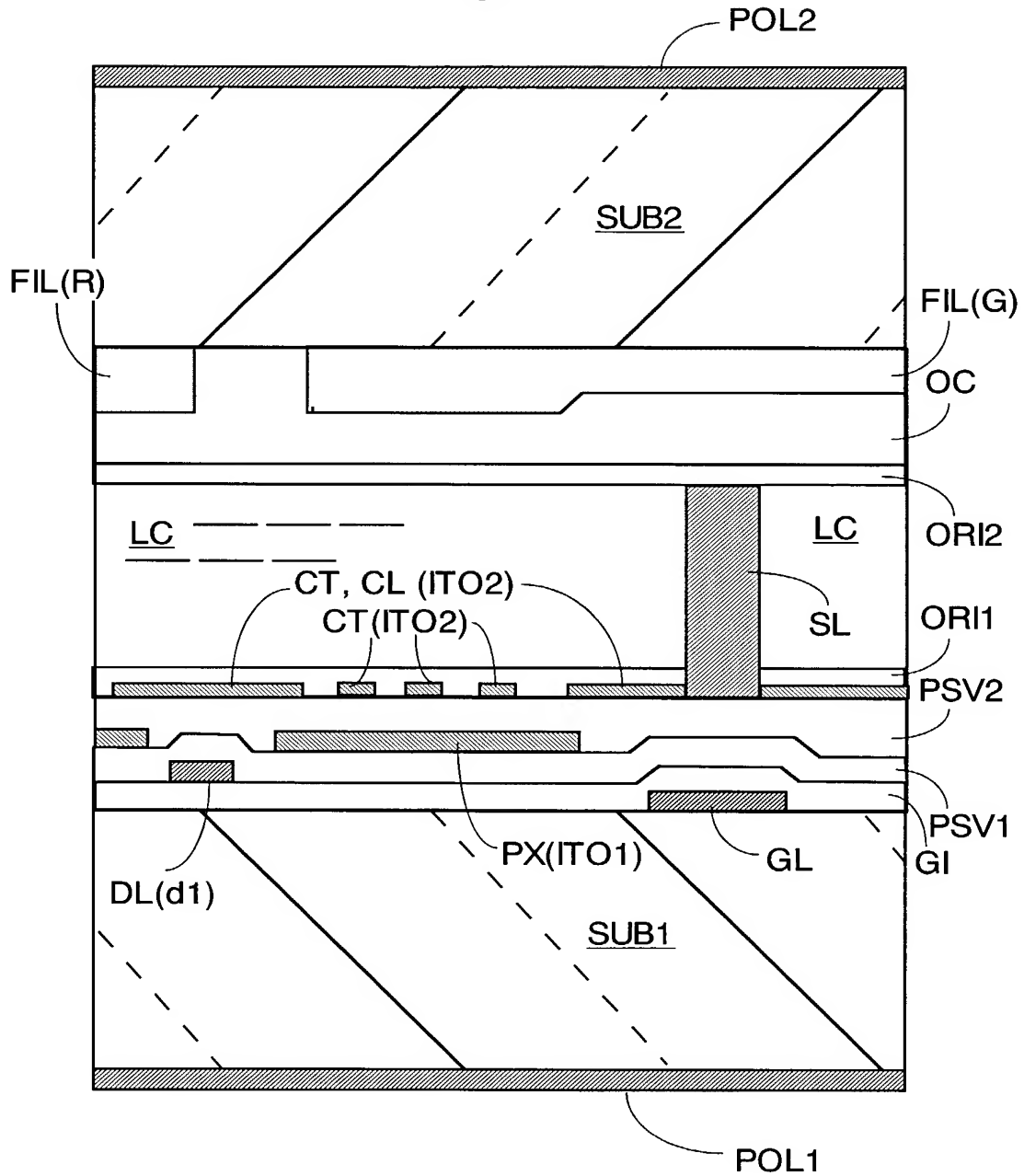


FIG. 42A

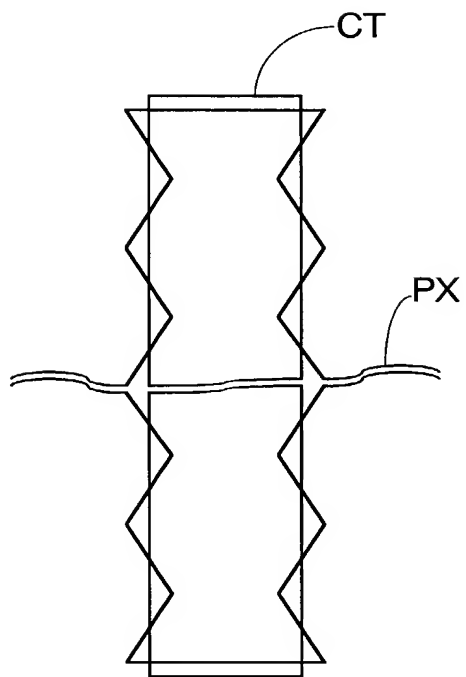


FIG. 42B

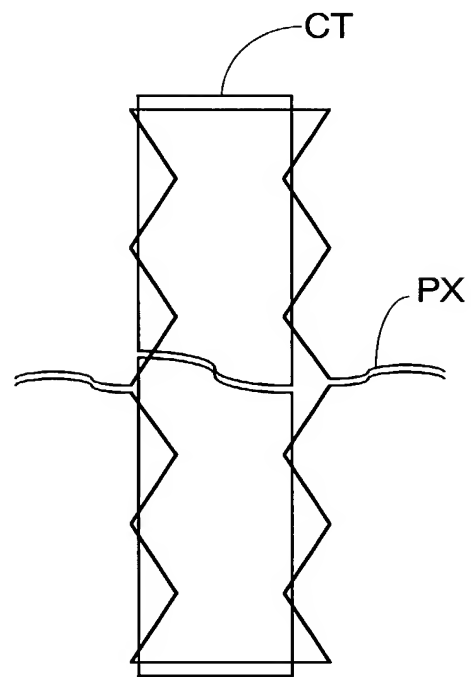


FIG. 43

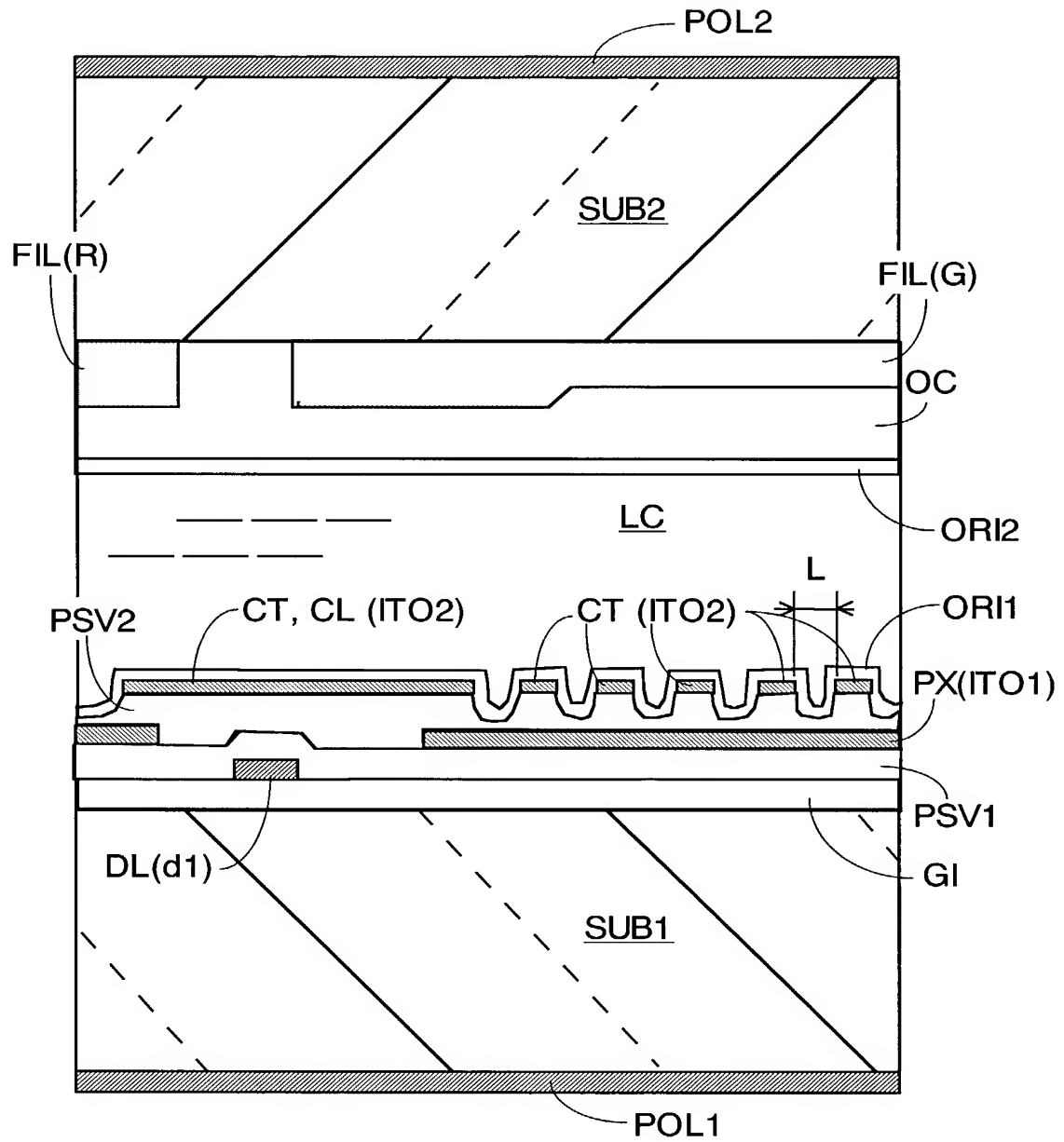


FIG. 44

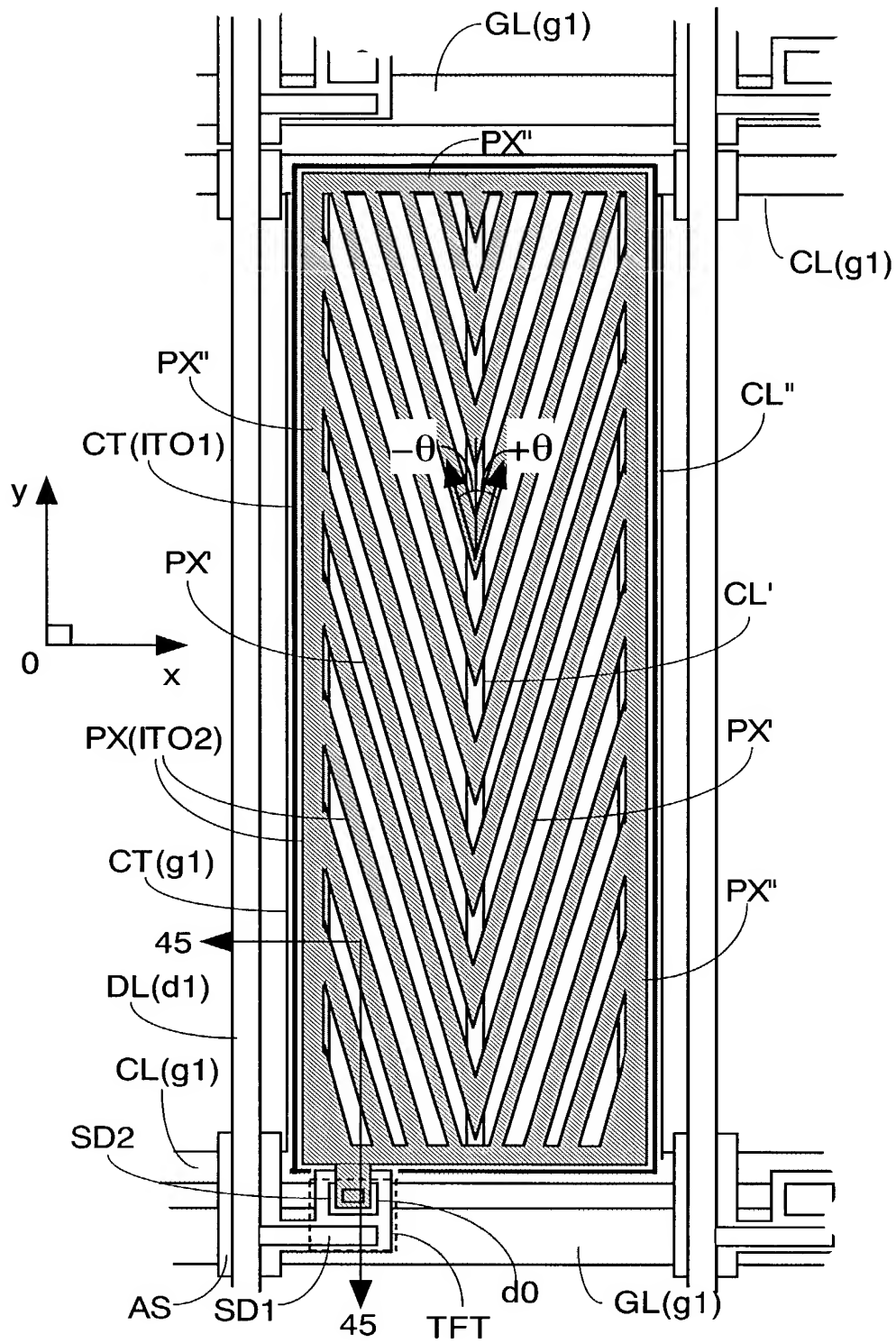


FIG. 45

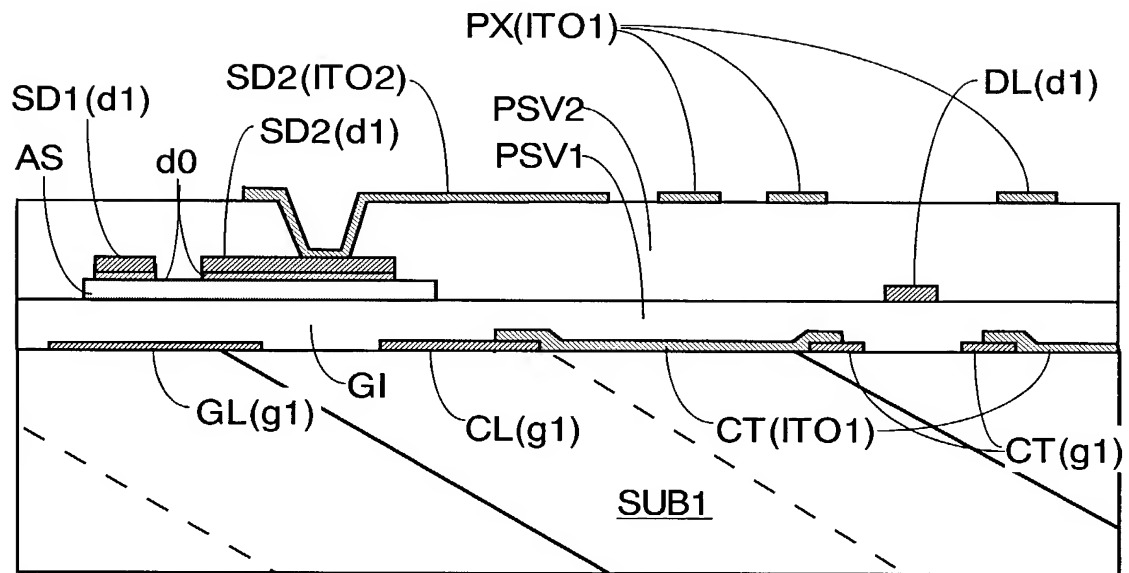


FIG. 46

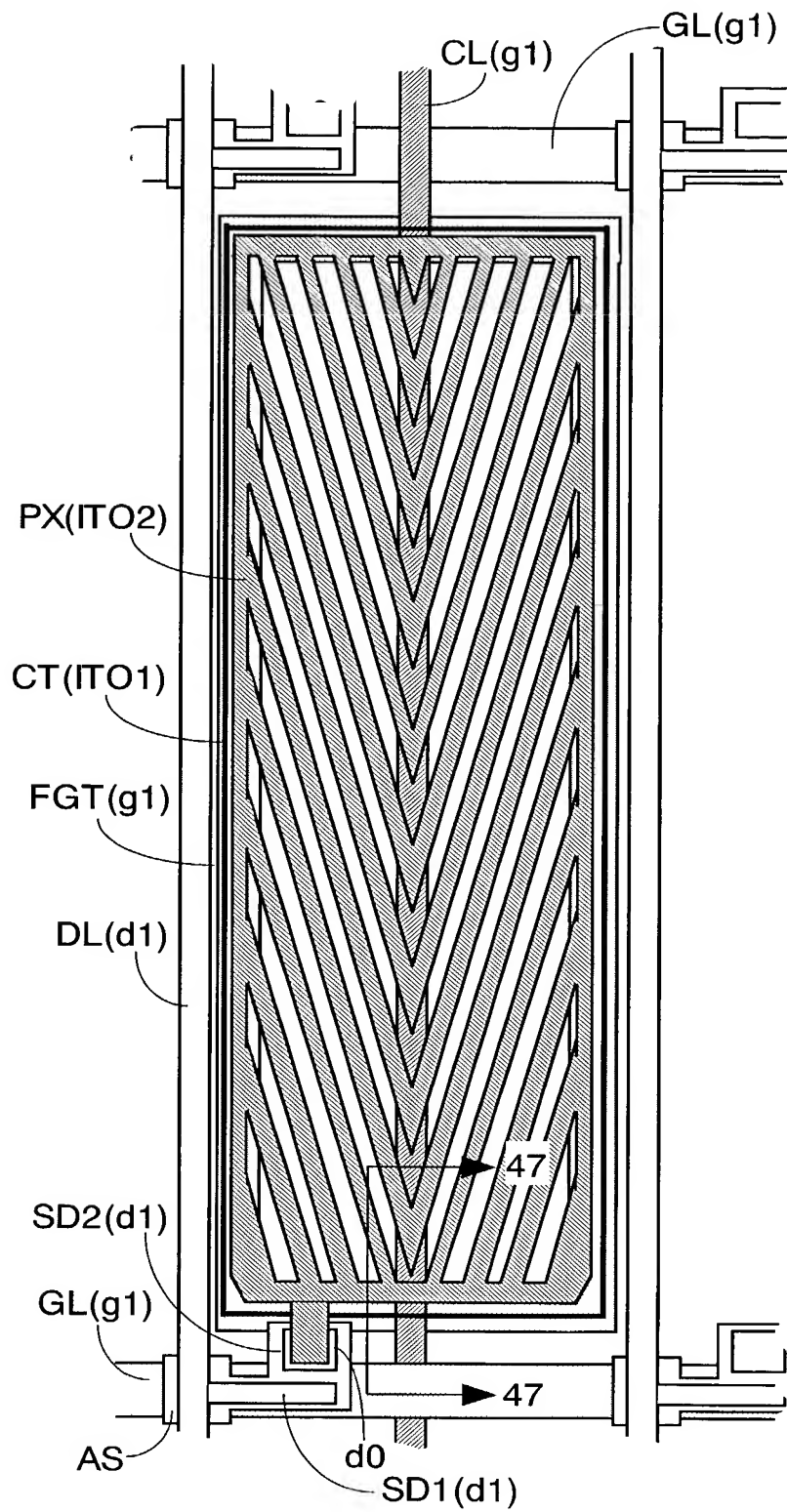


FIG. 47

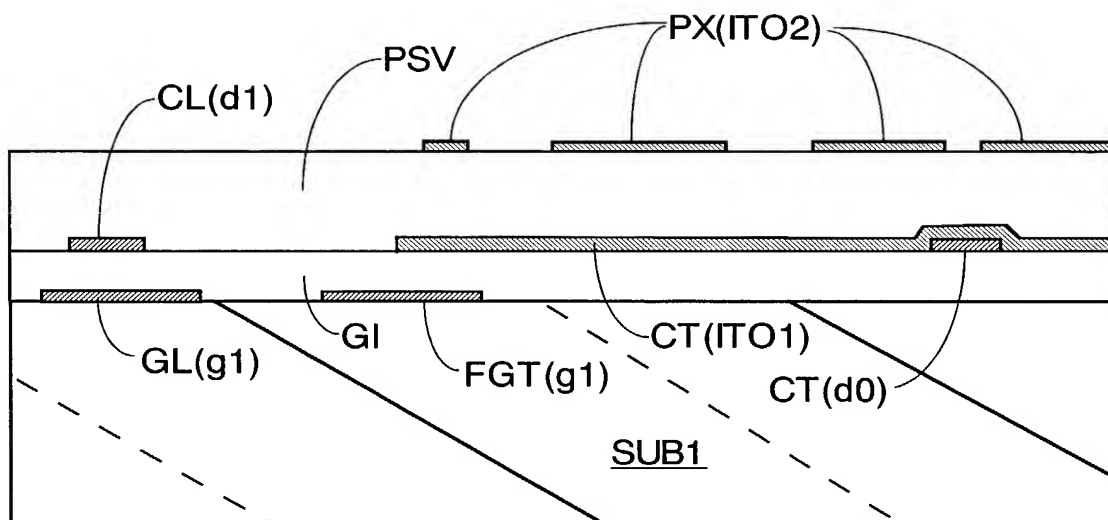


FIG. 48

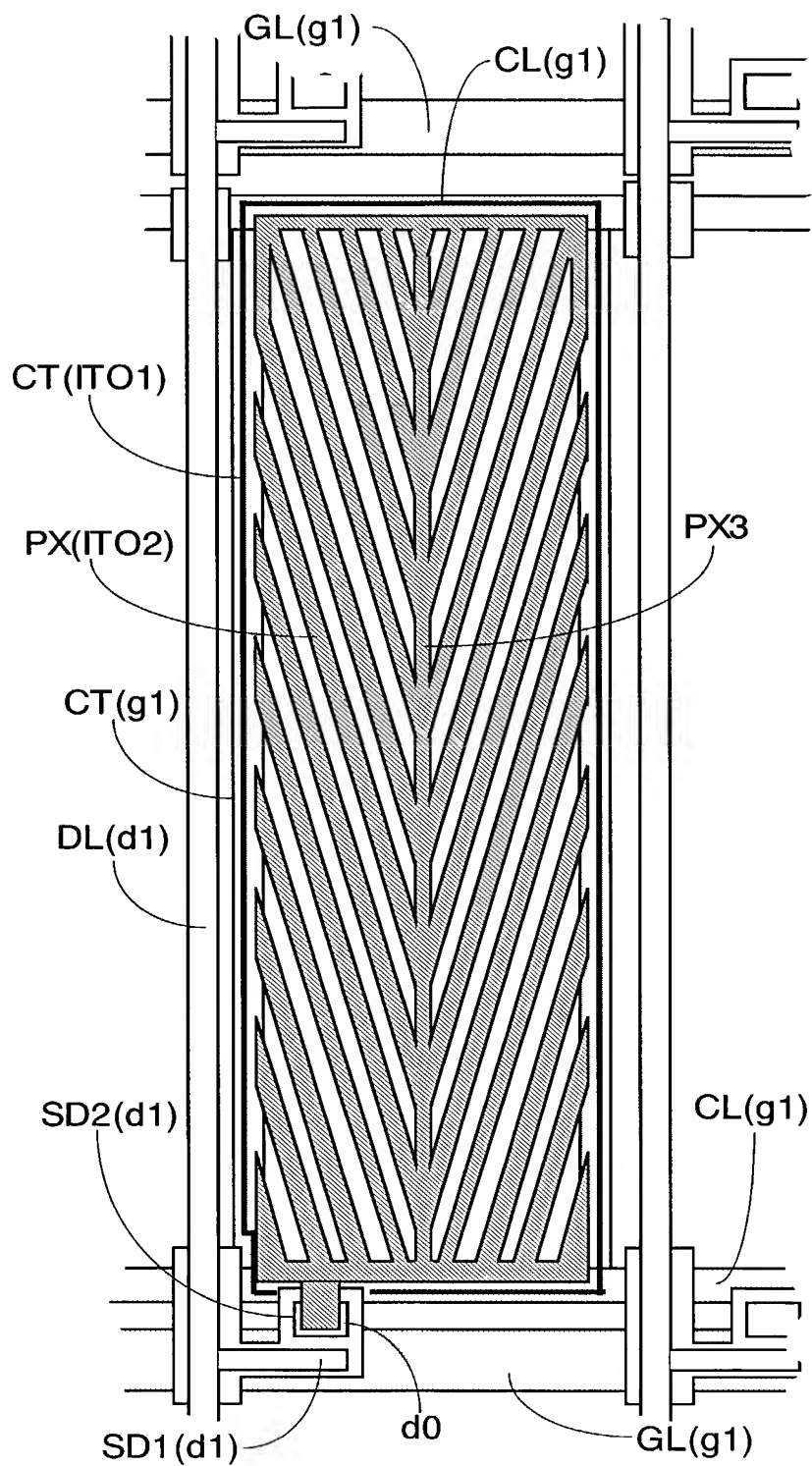


FIG. 49

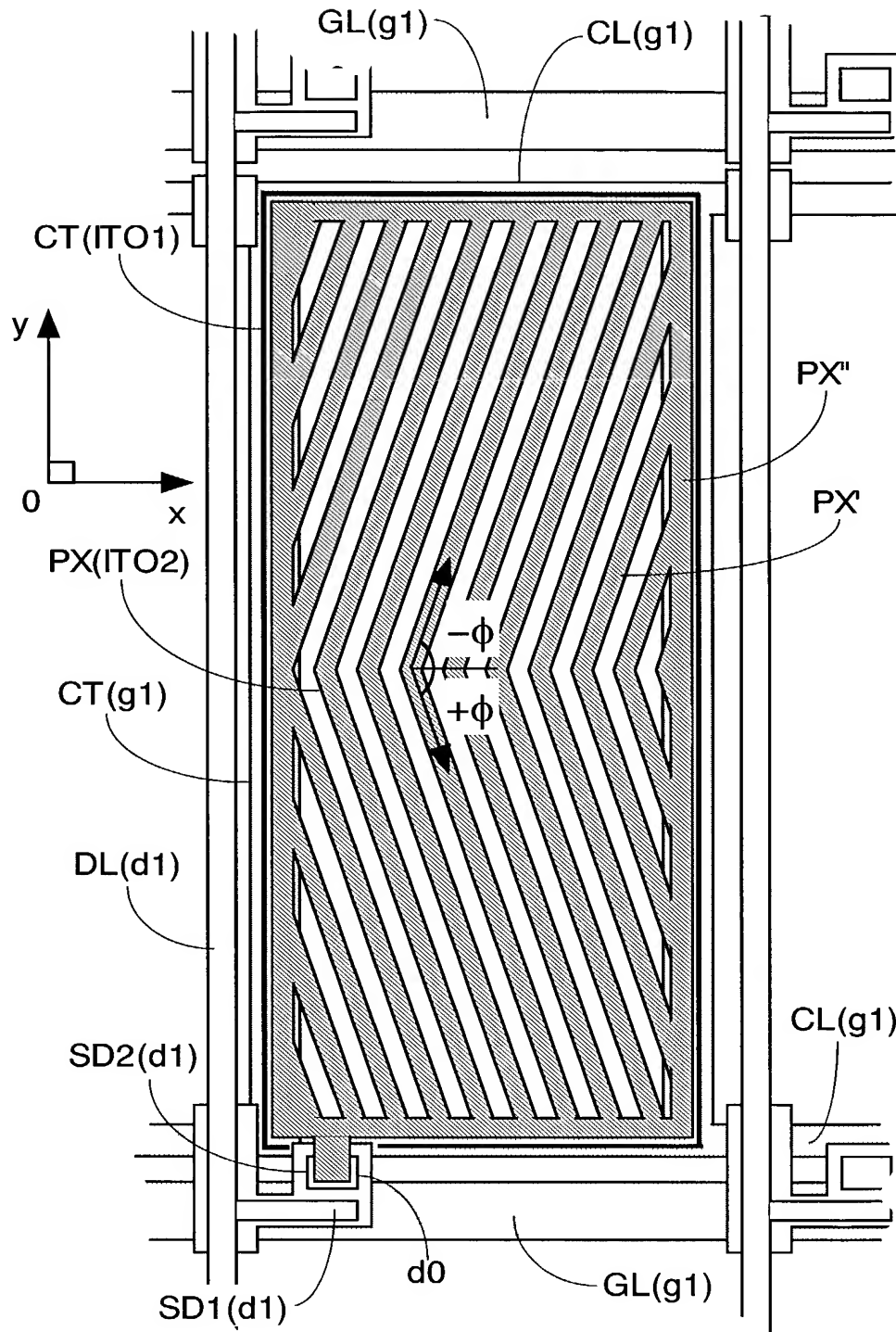
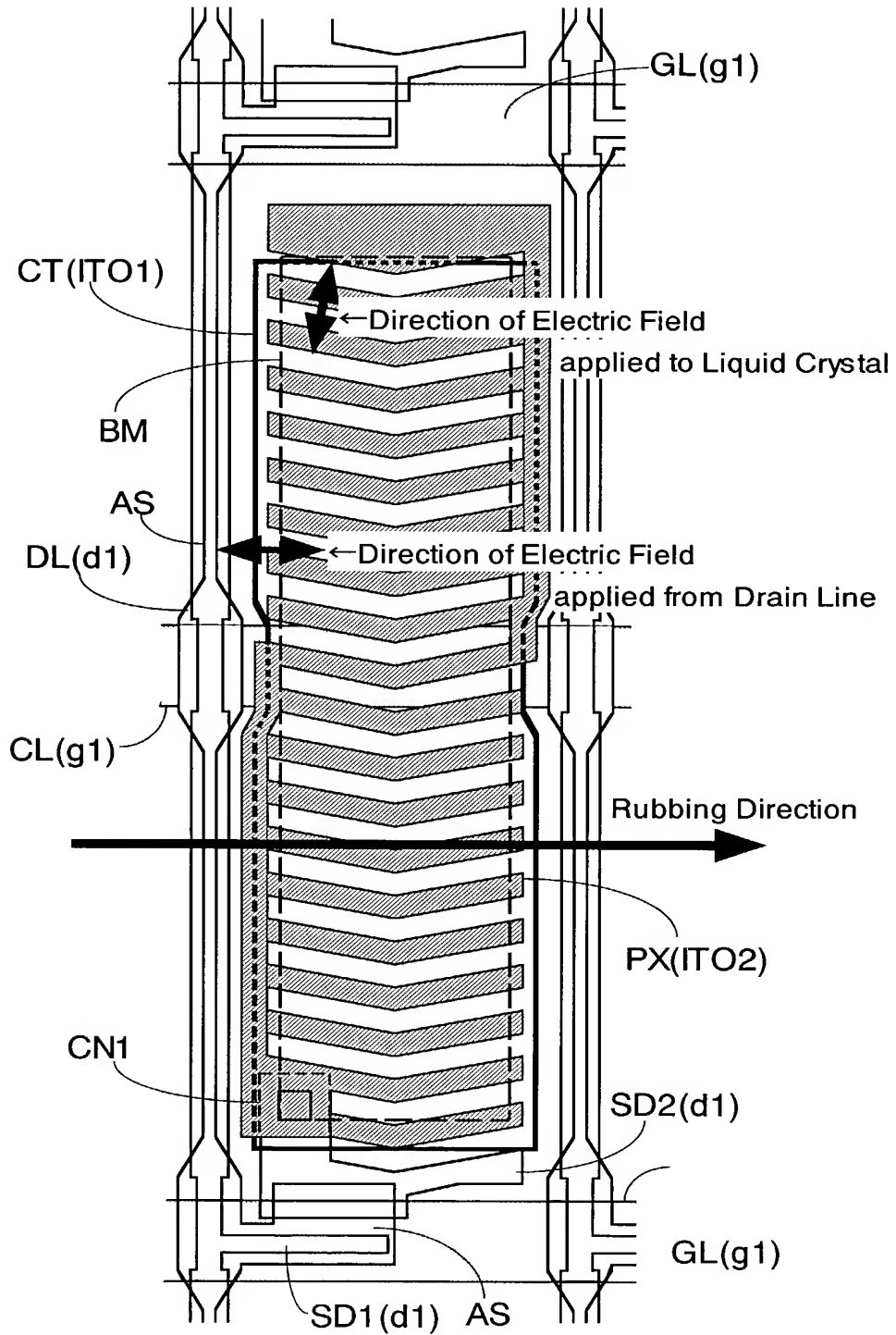


FIG. 50



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Japanese Language Declaration

(日本語宣言書)

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I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

外国での先行出願

<u>PCT / JP00 / 06009</u>	<u>Japan</u>
(Number)	(Country)
(番号)	(国名)
<u>11-252763</u>	<u>Japan</u>
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(出願年月日)

Priority Not Claimed

優先権主張なし

☐

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I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Application No.)
(出願番号)

(Filing Date)
(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

(Application No.)
(出願番号)

(Filing Date)
(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

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knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

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第二共同発明者	2-00	Full name of second joint inventor, if any <u>Makoto Yoneya</u>	
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(Supply similar information and signature for sixth and subsequent joint inventors.)